New Bedford Harbor Superfund Site

U.S. Army Corps of Engineers New England District

Draft Aerovox Interim Cap Field Sampling Plan

ACE-J23-35BG0708-M7-0001

July 2017

JACOBS

New Bedford Harbor Superfund Site

Project no:	35BG0708
Document title:	Draft Aerovox Interim Cap Field Sampling Plan
Document No.:	ACE-J23-35BG0708-M7-0001
Revision:	0
Date:	July 2017
Client name:	U.S. Army Corps of Engineers New England District
Project manager:	Steve Fox
Author:	Mike Morris

Jacobs
103 Sawyer Street
New Bedford, MA 02746
508-996-5462
508-996-6742
www.jacobs.com

Document history and status

Revision	Date	Description	By	Review	Approved

Table of Contents

Acronyms and Abbreviations v
1.0 Introduction 1-1
2.0 Background 2-1
2.1 Site Location and Description 2-1
2.1.1 Aerovox Background 2-1
2.1.2 Previous AVX Investigations 2-1
2.1.3 Previous New Bedford Harbor Remedial Actions 2-2
3.0 Pre-Design Data Collection 3-1
3.1 DNAPL Data Gap Sampling 3-1
3.1.1 Locations 3-1
3.1.2 Piston Core Sampling 3-1
3.1.2.1 Sediment Collection 3-2
3.1.2.2 Field Dye Test 3-2
3.1.3 Laboratory Analyses 3-2
3.1.3.1 Volatile Organic Compounds 3-3
3.1.3.2 Total PCBs 3-3
3.1.4 Schedule 3-3
3.2 Groundwater Flux Investigation 3-3
3.2.1 Methods 3-4
3.2.1.1 Preliminary Delineation of the Plume Discharge Area 3-4
3.2.1.2 Continuous Hydraulic Head Measurements 3-4
3.2.1.3 Discharge Zone Contaminant Concentrations 3-5
3.2.1.4 Schedule 3-5
3.3 Sediment Characterization for Groundwater Modeling 3-6
3.3.1 Locations 3-6
3.3.2 Data Collection 3-6
3.3.2.1 Deployment of Barge Mounted Sonic Rig 3-6
3.3.2.2 Field Collection of Sediment Samples 3-6
3.3.3 Laboratory Preparation of Sediment Samples 3-7
3.3.4 Laboratory Analyses 3-8
3.3.5 Schedule 3-10
3.4 Sediment Characterization for Engineering Design 3-10
3.4.1 Locations 3-10
3.4.2 Data Collection 3-11

3.4.3 Laboratory Analysis 3-11
3.4.4 Schedule 3-12
3.5 Gas Ebullition 3-13
4.0 Quality Assurance/Quality Control 4-1
4.1 Field Based Quality Control 4-1
4.1.1 Field Duplicates 4-1
4.1.2 Field/Equipment Blanks 4-1
4.1.3 Matrix Spike/Matrix Spike Duplicates (MS/MSD) for Organic Analyses and/or Matrix Spikes (MS) and Laboratory Duplicates for Inorganic Analyses 4-1
4.1.4 Trip Blanks 4-2
4.1.5 Temperature Blanks 4-2
4.1.6 Field Instrument Quality Control 4-2
4.2 Sample Handling and Custody Procedures 4-3
4.3 Decontamination 4-4
4.4 Quality Management and Nonconformance 4-4
5.0 Documentation and Reporting 5-1
5.1 Sample Identification 5-1
5.2 Reporting 5-3
6.0 Safety Procedures 6-1
7.0 Unanticipated Discovery of Cultural Remains 7-3
8.0 References 8-1

JACOBS

Figures

Figure 1-1	Site Location Map
Figure 2-1	Upper Harbor Showing Former Aerovox Property Location
Figure 2-2	Former Aerovox Site Area
Figure 2-3	PCB Distribution for Former Aerovox Site Area Shallow Soils/Sediments
Figure 3-1	Aerovox DNAPL Data Gap Sampling Locations
Figure 3-2	Aerovox Cross Section C-C' PCBs
Figure 3-3	Aerovox Drive point Locations
Figure 3-4	Aerovox Sonic Boring Locations

Tables

Table 3-1	Aerovox DNAPL Data Gap Locations
Table 3-2	Sample Containers, Preservation, and Laboratory Holding Times
Table 3-3	Aerovox Drive Point Locations
Table 3-4	Aerovox Sonic Boring Locations

Appendices

Appendix A	Immunoassay Lab Process Outline
Appendix B	Standard Operating Procedures
Appendix C	Example Chain of Custody Form

(intentionally blank)

Acronyms and Abbreviations

Aerovox Corp.	Aerovox Corporation
Aerovox Inc.	Aerovox Incorporated
ASTM	American Society for Testing and Materials
AVX	AVX Corporation
cm	centimeter
CSA	Comprehensive Site Assessment
cy	cubic yards
DNAPL	dense non-aqueous phase liquid
EE/CA	Engineering Evaluation/Cost Analysis
EPA	U.S. Environmental Protection Agency
FSP	Field Sampling Plan
f	total porosity
ft	feet
g/cm^3	grams per cubic centimeter
HDPE	high density polyethylene
Jacobs	Jacobs Engineering Group
IA	immunoassay
ID	internal diameter
in	inch or inches
K	hydraulic conductivity
LDPE	low-density polyethylene
$l/m^2/d$	liters per square meter per day
MassDEP	Massachusetts Department of Environmental Protection
MeOH	methanol
mg/kg	milligrams per kilogram
MIP	membrane interface probe

ml	milliliter
mm	millimeters
MS	matrix spike
MSD	matrix spike duplicate
NAE	U.S. Army Corps of Engineers – New England District
$NaHSO_4$	sodium bisulfate
NAPL	non-aqueous Phase Liquid
NETERC	New England Total Environmental Restoration Contract
oz	ounce
PCB	polychlorinated biphenyls
PFD	personal flotation device
PID	photoionization detector
PPE	personal protection equipment
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
ROD	Record of Decision
RPD	relative percent difference
RTK-DGPS	Real Time Kinematic Differential Global Positioning System
Site	New Bedford Harbor Superfund Site
SOP	standard operating procedure
SPA	Safe Plan of Action
TAT	turn-around time
TCE	trichloroethene
USACE	U.S. Army Corps of Engineers
USCS	Unified Soil Classification System
VOA	volatile organic analysis

VOC	volatile organic compound
°C	degrees Celsius
ρ_b	bulk density

1.0 Introduction

Under Task Order No. 0001 of the New England Total Environmental Restoration Contract (NETERC, No. DACW33-03-D-0006) for the U.S. Army Corps of Engineers (USACE) – New England District (NAE), Jacobs Engineering Group (Jacobs) will conduct remedial design and construction activities at the New Bedford Harbor Superfund Site (Site) in Bristol County, Massachusetts.

New Bedford Harbor is located in southeastern Massachusetts and is surrounded by the towns of New Bedford, Acushnet, and Fairhaven. Due to decades of industrial development and the improper disposal of wastes, particularly polychlorinated biphenyls (PCBs) and heavy metals, the harbor was added to the National Priorities List and named a U.S. Environmental Protection Agency (EPA) Superfund Site in 1983. NAE is managing the remediation for the EPA. The Site extends from the shallow northern reaches of the Acushnet River estuary, south through the commercial harbor of New Bedford and into Buzzards Bay (Figure 1-1). The 18,000-acre Site is divided into three areas: the Upper, Lower, and Outer Harbors (Figure 1-1). Work covered by this work plan will be limited to the Upper Harbor and the area adjacent to the Aerovox Site specifically.

All data collection activities will be conducted in accordance with NAE direction and approval. NAE will provide project Quality Assurance (QA), including a review of planning documents, data reports, and field oversight. Health and safety procedures and requirements are detailed in the Site Specific Safety and Health Plan (Draft, Jacobs 2017). Prior to daily sampling activities, a safe plan of action (SPA) will be developed and followed for the work and modified as needed with changing conditions. Field procedures are detailed in the Field Sampling Plan (FSP) (Jacobs 2012).

The purpose of this plan is to define and document sampling strategies and field procedures. The data collected as a result of this plan will be used to create a remedial design addressing the PCB-impacted sediment adjacent to the Aerovox property in New Bedford Harbor. The conceptual site model for New Bedford identified Aerovox as one of the main contributors of the PCBs in the harbor. Section 2 details the historic site activities and remedial efforts undertaken to date.

Section 3 identifies the sample collection methodology to determine the PCB concentrations in sediment, groundwater and contaminant flux from the Aerovox property, and physical harbor sediment characteristics. These data will be modeled to determine a sediment capping design engineered to protect the harbor. The field activities are tentatively scheduled to occur in August 2017. The 65% capping design is scheduled for draft submittal in November 2017.

(intentionally blank)

2.0 Background

The former Aerovox capacitor manufacturing plant at 740 Bellevue Avenue was the primary source of PCB discharges to the Acushnet River and New Bedford Harbor. The former facility consisted of a three-story textile mill, purchased in 1938 by Aerovox Corporation (Aerovox Corp.) and subsequently converted for capacitor manufacturing operations. Aerovox Corp., and a subsequent owner/operator, Aerovox Incorporated (Aerovox Inc.), used dielectric fluid containing PCBs in many of their products (capacitors) from the 1940s until a ban was placed on their use in the late 1970s. Aerovox Corp. and Aerovox, Inc. are now owned by AVX Corporation (AVX).

2.1 Site Location and Description

The Aerovox Site facility is located on an approximately 10.3-acre, industrially zoned parcel at 740 Belleville Avenue in New Bedford, Massachusetts. The facility (Figure 2-1), which directly abuts the harbor, consisted of a former three-story textile mill, purchased in 1938 by Aerovox Corp. and subsequently converted for capacitor manufacturing operations. Aerovox Corp., and a subsequent owner/operator, Aerovox Inc., used dielectric fluid containing PCBs in many of their products (capacitors) from the 1940s until a ban was placed on their use in the late 1970s. Aerovox Corp. and Aerovox Inc. also utilized trichloroethene (TCE) in the manufacturing process as a degreasing solvent (Versar 1981).

2.1.1 Aerovox Background

Inspections and sampling conducted at the Aerovox facility in the late 1970s and early 1980s led to a 1982 administrative order with EPA and a consent agreement with Massachusetts Department of Environmental and Quality Engineering (now named the Massachusetts Department of Environmental Protection [MassDEP]). The order required Aerovox Inc. to install protective measures preventing the migration of PCBs from the facility. These measures included installation of an asphalt concrete cap over impacted soils on the northeast and eastern sides of the property, and the installation of a sheet pile wall along the shoreline of the Aerovox property. These controls were to isolate impacted soils and groundwater from the harbor. These actions were implemented in 1983-1984 (Gushue and Cummings 1984). A subsequent 1984 agreement between Aerovox, Inc., EPA and MassDEP required a long-term monitoring and maintenance program to control and document on-site contamination and prevent the migration of PCBs.

2.1.2 Previous AVX Investigations

A site inspection by EPA in 1997 (and an EPA Approval Memorandum in 1998) lead to an Engineering Evaluation/Cost Analysis (EE/CA) conducted by Aerovox Inc. at the Aerovox Site that revealed extensive PCB contamination within the plant. The EE/CA recommended building demolition with onsite and offsite disposal of PCB-contaminated building debris, followed by capping (BBL 1998).

In March 2006, EPA prepared a conceptual site model, which provided a summary of available information regarding PCB contamination present at the Aerovox Site (ENSR 2006). Existing site data were reviewed, and a limited investigation was performed to provide information on storm water runoff as well as groundwater beneath the Aerovox Site. The data provided a screening-level assessment of PCB transport from the Aerovox Site to the adjacent waters of New Bedford Harbor. ~~The data indicated a very low potential for significant transport~~ (ENSR 2006); however, the ~~assessment noted~~ that building deterioration could increase the potential for ~~mobilization and transport of PCBs.~~

AVX submitted a Phase I Initial Site Investigation, Tier Classification, and Phase II Scope of Work in August 2013. MassDEP issued a Tier 1B Permit for the Aerovox Site and conditional approval of the Phase II scope of work in September 2013. Site investigations for the Phase II Comprehensive Site Assessment (CSA) were conducted between October 2013 and August 2015.

The Phase II investigations identified subsurface areas within the Aerovox Site and New Bedford Harbor that have contamination related to the former site activities. In addition, dense non-aqueous phase liquid (DNAPL) was identified on the Aerovox site and in the harbor. In one location, DNAPL found near the shoreline has migrated to top of bedrock. Two areas of DNAPL (Figures 2-2 and 2-3) were investigated *and are aligned with the points of discharge from historic Aerovox drainage ditches*. The larger northern DNAPL area is *~0.25 acres* and is located at 10 feet (ft.) below the harbor sediment surface. The second DNAPL area encompasses *~0.10* acres and is *located 5 ft. below* the harbor sediment surface. The Phase II determined the maximum PCB concentration on site is found in the northern DNAPL area with 27,100 milligrams per kilogram (mg/kg) total PCBs. The Phase II investigation concluded that contamination remaining on the Aerovox Site has the potential to migrate into the harbor sediments if left unaddressed.

The Phase III remedial action plan was submitted in August 2016 and included evaluation of a number of remedial action alternatives. The Phase III plan was reviewed and found to be deficient on February 7, 2017. A revised Phase III was submitted in July 2017 and is currently under review.

2.1.3 Previous New Bedford Harbor Remedial Actions

In 2008, approximately 6,900 cubic yards (cy) of highly contaminated sediment abutting the Aerovox shoreline was removed using land-based mechanical excavation (Jacobs 2009a). This work was done as part of the remediation conducted pursuant to a 1998 Record of Decision (ROD). The area of the harbor east of the Aerovox shoreline was hydraulically dredged in 2009 and 2010. A total of 26,000 cy were removed during this effort (Jacobs 2010b, 2011).

(intentionally blank)

3.0 Pre-Design Data Collection

This section addresses the methods for collecting samples to support sediment characterization as well as design for an interim cap east of the Aerovox shoreline. One investigation will determine whether historic sampling adequately characterized the extent of DNAPL in the harbor sediments. A second investigation will be implemented to determine where groundwater from the Aerovox site is discharging to the harbor and characterize the flux of contaminants from the sediment into the harbor. A third investigation, a roto-sonic drilling program, will be initiated to collect and characterize sediment samples for physicochemical parameters concerning the development of a groundwater flow and transport model for the harbor. A series of samples co-located with the sonic borings will be collected by push core to characterize the engineering properties of the sediment in anticipation of the placement and design of an interim cap.

These three investigations are described below.

3.1 DNAPL Data Gap Sampling

The DNAPL data gap sampling investigation will determine the extent of DNAPL in the native deposits below the organic layer. This will be performed at locations off-set from the 2012 and 2015 shoreline investigation (Jacobs 2017) to determine whether the location of DNAPL has been adequately characterized. To date, DNAPL has been found within monitoring wells MW-15D and UV-17 on the Aerovox site (AECOM 2015), and in boring ASB-16 within the harbor (Jacobs 2017). Concentrations of PCBs greater than 20,000 mg/kg have been found in Aerovox soils from MIP-53 and MIP-54 (AECOM 2015). The current distribution of PCBs is presented in Figure 2-3 and shows that potential PCB contamination extends from the Aerovox site into the harbor. This sampling effort is designed to investigate the concentration of PCBs in the shallow sediments outside the areas previously investigated to determine whether the current interpretation is adequately characterized.

3.1.1 Locations

DNAPL Data Gap Samples will be collected from 13 locations in the harbor. These are locations outside of the current footprint of the 2012 and 2015 investigations and are necessary to confirm the extent of DNAPL in the harbor sediments. These locations are south, east, and north of the furthest extent of the previous coring programs. The location of these samples is presented in Table 3-1 and Figure 3-1.

If DNAPL is found in any of the data gap locations, a step-out location will be determined and another core will be collected.

3.1.2 Piston Core Sampling

A piston core sampler will be deployed to collect sediment samples at each location. The piston core device will be supplied with a 2.75-inch (in) polycarbonate core barrel. The sampling of sediment will follow Jacobs Standard Operating Procedure (SOP) Tech-022 *Sediment Sampling* (Jacobs 2012). The locations will be accessed by boat and the locations confirmed by Real Time Kinematic-Differential Global Positioning System (RTK-DGPS). A pontoon boat with a moon pool will be use to access the coring locations. The sampler will be deployed through the moon-pool. Immediately prior to core collection, a water level will be collected by a stadia rod and the water elevation will be documented by a dedicated water level meter placed on a sheet pile near Aerovox. If the core collection process is elongated, the water level will also be recorded after the core collection. The piston core will be placed on the harbor bottom and the device will be advanced by hand to refusal, usually about 3 to 3.5 feet (ft) below the top of the sediment surface. The device will be withdrawn and presence of native material (gray marine sediments) will be confirmed.

ft? ft?

3.1.2.1 Sediment Collection

would sample more intervals

The sample will be extracted into a clean, decontaminated plastic gutter and will be described according to the Unified Soil Classification System (USCS) prior to sampling. Samples will be collected from the top 0.5 inches of the surface or OL layer and the bottom 0.5 inches of the native or gray marine sediments. Samples will be placed in appropriate containers (Table 3-2 and Section 3.1.3) and placed in a cooler for transport. The samples will be tested for total PCBs by Immunoassay (IA) analysis (Appendix A) and for volatile organic compounds (VOCs) by EPA method SW8260C. All activities, including sediment descriptions, will be recorded in a field logbook according to Jacobs SOP Tech-035 *Field Logbook* and the descriptions of each boring will be recorded in a log based on Jacobs SOP Tech-12 *Boring Log Development* (Jacobs 2012).

3.1.2.2 Field Dye Test

A hydrophobic dye (such as Oil Red O) will be used to determine whether non-aqueous phase liquid (NAPL) is present in the samples. This procedure is performed in the field; and results recorded at the time of the test. A small portion of the 0-0.5 ft interval from top of native and 0.5 ft interval at bottom of core will be placed in a clear glass jar with a portion of the dye and visual observation will determine whether any NAPL is present in the sample. The sample will be placed in a sample jar and a suitable dye will be introduced (e.g., Sudan IV, Oil Red O). The jar will be capped and then vigorously shaken. A bright red coloration appears in the presence of NAPL. This test will be conducted on the boat and will be consistent with the procedure outlined in EPA (2004).

what method? IA 3.1.3.2

3.1.3 Laboratory Analyses

The sediment samples collected for the DNAPL characterization will be submitted for PCBs and VOC analyses. In addition, one out of every ten samples will be submitted to an offsite laboratory for PCB analysis using EPA SW-846 Method 8082 for Aroclors. These sediment samples will be packaged, placed on ice, and shipped under custody to the offsite laboratory. Sample packaging and shipment will be conducted in accordance with the SOPs outlined in the FSP (Jacobs 2012).

∴ 3 samples? (2.13-26)

3.1.3.1 Volatile Organic Compounds

what depths? 3.1.2.1?

Samples for VOC analysis will be collected from the section before all other samples to minimize the loss of the VOC compounds to the atmosphere and disturbance. Collection of laboratory samples for VOCs will be performed using a 5 milliliter (ml) syringe sampler. The syringe will be used to collect approximately 2 to 3 ml of sediment from the core section and deposit sediment into 40 ml volatile organic analysis (VOA) vials. A total of three vials will be collected per VOC sample; two preserved with sodium bisulfate ($NaHSO_4$) and one with methanol (MeOH). Once sediment is added, each VOA vial will be immediately capped with the appropriate cap and VOC septum.

3.1.3.2 Total PCBs

Samples for PCBs will be collected in an 8-ounce (oz) glass jar, placed in a cooler and transferred to the onsite IA laboratory for analysis. The samples will be homogenized and a 35- to 40-gram aliquot will be oven dried for a minimum of 12 hours. A 10-gram aliquot of the dry sediment sample will be analyzed for total PCBs by IA (EPA method SW4020). IA is a rapid turnaround technique that measures the concentration of PCBs in a solution through an enzyme-linked color change assay that measures the total concentrations of PCBs rather than either Aroclors or individual congener species (Appendix A).

3.1.4 Schedule

The schedule for events includes 2 to 3 days of collection/processing samples and 2 to 3 days of analysis for PCBs. Preliminary data from the VOC analyses is expected after 10 working days from submittal. Field work is anticipated to begin in early August of 2017.

Samples will be submitted for standard turn-around time (TAT), whereby preliminary data should be available in 10 days and final results available in 14 days.

3.2 Groundwater Flux Investigation

Elevated concentrations of PCBs and VOCs (including DNAPL) released from the Aerovox site have been identified in subsurface sediments beneath the Upper Harbor (Figure 2-1). These highly contaminated sediments extend up to 300 feet offshore and have been identified at depths up to 20 feet below the harbor bottom (Figure 2-3 and Figure 3-2). The advection of groundwater through these highly contaminated sediments with subsequent discharge to the Upper Harbor could represent a potentially significant long-term source of PCB contamination. Consequently, the primary objectives of the groundwater discharge zone and contaminant flux investigation are to:

- Map the area offshore from the Aerovox site where groundwater is discharging to the Upper Harbor.

- Characterize the areal distribution and concentrations of PCBs and VOCs within the groundwater discharge zone.
- Determine the extent that the tide cycle affects groundwater heads and the concentrations of PCBs and VOCs in the discharge zone.

Once these data have been obtained, they will used in the development of a numerical hydrological and fate and transport model for the Aerovox site. This will be used to calculate the steady state flux of contaminants through the discharge zone and to support cap design and performance testing.

3.2.1 Methods

The methods used for this investigation include measurement of hydraulic head information from drive points and stationary wells. It also includes the analysis of physicochemical and chemical parameters collected from groundwater from these drive points.

3.2.1.1 Preliminary Delineation of the Plume Discharge Area

Water temperature data collected at the sediment-water interface can be used to identify areas where cooler groundwater is discharging to warmer surface water. This approach will be used to generally define the extent of the area offshore of the Aerovox site where potentially contaminated groundwater is discharging into the Upper Harbor.

Temperature data will be collected during low tide (+/- 1.5 hours) from the sediment-water interface at the 55 locations shown in Figure 3-3 (Table 3-3). Collection of these data within the required window of time around low tide may require collection over two or three tide cycles. The measuring device will consist of a temperature probe ensconced within a protective flow-through housing (e.g., a perforated PVC pipe) that is securely attached to the bottom of a stadia rod or a long pole. The probe will be extended to the sediment-water interface at each location and allowed to equilibrate with the ambient water prior to recording the results. Changes in the bottom water temperature from location to location should generally correspond to variations in the upward flux of groundwater at each location. The operation of the water quality instrument will be conducted in accordance with SOP Jacobs Tech-011 *Field Measurements Using the YSI 6820 or 6920 Water Quality Meter* (Jacobs 2012). The data obtained by the preliminary field water quality investigation will be used to refine (if necessary) the proposed temporary drive point well clusters and the push point water sampling locations discussed below.

3.2.1.2 Continuous Hydraulic Head Measurements

Continuous groundwater head measurements will be used to estimate the flux of groundwater and contaminants to the Upper Harbor from the Aerovox shoreline. These data will be primarily obtained from four monitoring wells, including three shallow wells (above bedrock) and one deep well (to bedrock). Each well will be fitted with a transducer that will continuously log water levels during the course of the drive point investigation in the harbor. These wells include MW-4, MW-7, MW-19S, and MW-17D (Figure ~~3-3~~). A continuous water level meter

not shown 2-2

will be placed in the harbor near the Aerovox location that will be monitored during the head measurement phase to document the magnitude and length of each tidal cycle during the investigation.

3.2.1.3 Discharge Zone Contaminant Concentrations

Pore water samples will be collected by drive point. The proposed drive point locations are spaced on 50-ft centers and form a grid over the highly contaminated subsurface sediments that extend offshore from the Aerovox site (Table 3-3 and Figure 3-3). Installation, hydraulic measurements, and sample collection will occur in compliance with Jacobs SOPs Tech-006 *Water Level Measurement* (Appendix B), Tech 011-*Field Measurements using the YSI 6820 and 6920 Water Quality Meter*, Tech-015 *Groundwater Sampling* (Jacobs 2012), Tech 020-*Field Filtration of Water* (Appendix B), Tech-030 *Drive Point Groundwater Sampling* (Appendix B), and Tech-064 *Small Diameter Well Installation* (Appendix B).

Decontaminated stainless steel push point samplers, or equivalent, will be used to collect water level data and pore water samples at depths of 1 ft and 3 ft below the sediment surface at each of 55 surface locations (Figure 3-3). After the water level data have been collected, groundwater samples will be extracted using a peristaltic pump with ¾" internal diameter (ID) low-density polyethylene (LDPE) tubing. Inline 1.0-micon filters will be used to remove particulates from the extracted groundwater. The small diameter of the sampling devices and the shallow sampling depths increase the potential for groundwater to be mixed with surface water during sampling. In order to minimize this potential source of error, the total volume of water extracted from each location, and the rate that it is extracted, will be minimized as much as is practicable. As a check for potential surface water influx during sampling, water quality parameters will be collected immediately before sampling begins and again immediately after sampling is completed. The sample collection and preservation requirements are presented in Table 3-2. The analytes for this sampling effort include:

- Total PCBs (as Aroclors)— EPA SW8082A
- Total VOCs—EPA SW8260C
- Methane—RSK 175
- Sulfide—SW9030B
- Total Dissolved Metals (Ca, Mg, Na, K, Fe, Mn)—EPA SW6010C
- Sulfate-Chloride-Nitrate—E300.0
- Total Alkalinity—E310.1
- Dissolved Organic Carbon—E415.1

3.2.1.4 Schedule

The schedule for this effort will begin in early August 2017. A 3- to 4-week effort for sample collection is anticipated to complete the groundwater flux investigation.

Samples will be submitted for standard TAT, whereby preliminary data should be available in 10 days and final results available in 14 days.

3.3 Sediment Characterization for Groundwater Modeling

Sediments will be evaluated for their characteristics and the applicability to supporting a groundwater model for the discharge to the harbor. A series of three sonic borings will be used to collect these data. Previous investigations have identified five major stratigraphic layers that may be used as layers in the groundwater model. These include: OL; marine deposits; glacial outwash; glaciolacustrine deposits; and glacial till. These stratigraphic units will be sampled from three borehole investigations if they meet the depth criteria described in the following sections.

3.3.1 Locations

explain rationale for siting

The three sonic borings will be installed to capture the variability of sediments within the harbor east of the Aerovox sheet pile wall. The locations are oriented roughly northeast to southwest and approximately 180 ft apart. The orientation was chosen to specifically capture those locations that are most likely to be covered by the interim cap. Table 3-4 shows the northings and eastings of each location and Figure 3-4 shows the locations in relation to the shoreline investigations (Jacobs 2017).

3.3.2 Data Collection

The samples will be collected by roto-sonic boring through the sediments of the harbor. Past investigations have shown the depth to bedrock varies between 20 and 30 ft dependent on location. Sonic boring has been shown to be the most efficient method capable of easily penetrating the variable stratigraphy even into and through the glacial till. Sonic boring provides a continuous, undisturbed soil profile and can penetrate even into bedrock.

3.3.2.1 Deployment of Barge Mounted Sonic Rig

~~Previous~~ sediment borings will be collected using a mini-sonic 200C drill rig or equivalent. The mini-sonic drill rig will be securely mounted on a self-propelled barge equipped with a moonpool, spuds, crane, and support vessel. Horsepower of the barge will be controlled to minimize prop wash and turbidity. The sonic rig and sample collection will be performed according to Jacobs SOP 002—*Monitoring Well/Piezometer Installation* (Jacobs 2012).

3.3.2.2 Field Collection of Sediment Samples

All boring locations will be confirmed with a RTK-DGPS. Once on station, the barge will be secured using spuds. A continuous water level meter will be accessed to determine water elevation during the boring procedure. The water depth will be determined by stadia rod.

All tooling and drill bits will be decontaminated on the barge prior to use at each boring station according to Jacobs SOP Tech-036 *Equipment Decontamination Procedures* (Jacobs 2012). The decontamination procedure will be a three-step process using: 1) an initial steam power washer cleanse; followed by 2) scrubbing with Alconox detergent; and 3) a final steam power wash rinse. All decontamination runoff will be captured into drums for proper waste disposal.

Prior to sediment boring, the subsurface will be cased off to the top of the desired boring elevation. During this casing advancement, high pressure water will be injected from the drill head down through the casing to remove soil cuttings and prevent heave. Once the casing has reached the desired depth, the core barrel will then be lowered within the casing to the top of the boring elevation and advanced (vibrated) into undisturbed sediment. The length of the core will be compared to the penetration depth to measure core recovery. If there is less than 100% recovery, the potential location of loss will be noted for use in calculating elevations. This process will be repeated until the top of bedrock is encountered and the boring terminated.

Sonic drill rig borings will be cased and drilled to bedrock, or to estimation of bedrock based on drilling characteristics. Bedrock will not be penetrated. Sediments will be collected in 5-foot core sections within Lexan liners. Immediately upon recovery, the ends of the boring liners will be capped with a high density polyethylene (HDPE) core tube cap. The cap will be secured in place using tape. Capped Lexan boring sections ~~were~~ will be labeled in permanent maker to denote:

- Boring ID
- Depth Interval (e.g., 15.0' – 20.0')
- Upper End (marked with an arrow pointing upward)
- Date and Time of Collection
- Presence of photoionization detector (PID) readings for VOCs

If the core is cut to shorter lengths, a cleaned, decontaminated sabre saw or hack saw will be used to cut the Lexan liners. Following the cut, each exposed liner end will be capped using the process described above. Core sections will be stored in a vertical position until transferred to the on-site field laboratory for analytical subsampling and geological descriptions. Following the completion of sample collection, the borehole will be sealed with bentonite from the top of bedrock to the water/soil interface.

3.3.3 Laboratory Preparation of Sediment Samples

Upon return to the laboratory, the cores within the Lexan tubing will be examined visually prior to opening. For each stratigraphic component, the core will be assessed to the thickness of each unit. If the stratigraphic section is 8 to 10 in in thickness, a type-section from each core will be determined and the most representative section will be selected. Using a clean hacksaw, the Lexan liner and core will be cut to 8-in to 10-in lengths and re-capped. The whole 8- to 10-in section will then be submitted to the laboratory for analysis using Jacobs SOP Tech 028-*Packing and Shipping of Environmental Samples* (Jacobs 2012).

OL. The OL is a soft, dark, highly organic layer that overlies a series of marine deposits. Much of this layer has been removed in previous dredging operations, but residuals do remain. This is the layer that typically has the highest concentrations of PCBs in harbor sediment due to the affinity for these compounds to partition into the organic materials.

Marine Sediments. Marine sediments are a gray, fine-sandy to silty layer that underlies the OL and overlies a series of glacial outwash deposits. These are post-glacial deposits that formed during post-glacial and when the original landscape was drowned as a result of rising sea levels. The unit is generally well sorted and has variable amounts of clay. A layer of peat is occasionally found under this unit and represents the residual wetlands that previously existed as the water levels in the harbor rose from deglaciation. The peat is common on the land side of the sheet pile wall, but very discontinuous in the harbor (Jacobs 2017).

Glacial Outwash. Glacial outwash is a sandy to gravelly deposit that formed from the influx of glacial meltwater forming braided stream regimes in the valley. The deposits are generally brown to yellow. The unit can have traces of red in the uppermost portion where a paleosol may have formed.

Glaciolacustrine Deposits. Glaciolacustrine Deposits are silty to clayey and are brown to grey in color. These are silty glaciolacustrine deposits interspersed within the outwash that represent low energy pro-glacial deposits as the glaciers stagnated and retreated. These layers may provide a low-flow barrier in comparison to the more open glacial outwash deposits.

Glacial Till. Glacial till is a gravelly, clayey deposit originating from ice-contact with the basal bedrock and sediments. This unit is dense, poor sorted, and poorly oriented. The gravels are generally angular and exhibit frost fracturing and were deposited without any apparent orientation. The unit is gray to green in color and generally stiff in consistence. The till usually overlies bedrock which is generally an igneous base composed of varying degrees of granite, granodiorite and diorite.

3.3.4 Laboratory Analyses

The whole stratigraphic section, cut into 8- to 10-in pieces, will be submitted to the laboratory intact in order to preserve the undisturbed features of the sediment. The laboratory will sub-section or sub-sample the section as necessary to perform the analytical assessment.

Bulk Density. Bulk density (ρ_b) is the ratio of the mass of soil to its total volume. This measurement is used to determine the amount of available pore space and is used to estimate total porosity (f) which in turn reflects space that may be available for fluid transport. The analytical method will be American Society for Testing and

Materials (ASTM) Method D2937 *Standard Test Method for Density of Soil in Place by the Drive-Cylinder Method* (ASTM 2017).

Particle Size. Particle size analysis is a measure of the relative sizes of particles that comprise the sediment matrix. It is generally broken down into particles less than 2 millimeters (mm) in diameter and is further divided into sand (sieve), silt (hydrometer), and clay (hydrometer) sized particles. This information is used to help calibrate the groundwater model as flow is generally more rapid through larger particle sizes (sand) than smaller particle sizes (silt and clay). The analytical method will be ASTM Method D422 *Standard Test Method for Particle-size Analysis of Soils* (ASTM 2007).

Atterburg Limits. Atterburg limits measures critical water content of a fine grained soil and determines the liquid limit, shrinkage limit, and plastic limit. The analytical method will be ASTM Method D4318 *Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils* (ASTM 2010b).

Soil Classification. Soil classification is an analysis that characterizes the soil or sediment based on its physical properties, such as particle size distribution. This provides an accurate designation of the USCS soil classification designation and is used to determine the engineering properties of the sediment. The analytical method will be ASTM D2487 *Standard Practice for Classification of Soils for Engineering Purposes* (ASTM 2011a).

Soil Moisture. Soil moisture is the amount of water in the sediment in comparison to the solid fraction. This can be done on a mass or volume basis. The analytical method will be ASTM D2216 *Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass* (ASTM 2010a).

Total Carbon. Total carbon is a measure of the total organic (plant and animal remains) plus the total inorganic (carbonate) content of the sediment. In areas where carbonate content is low, it is a general measure of the amount of organic carbon. This carbon content affects structure and consistence and is an important measure for the ability of the sediment to partition organic compounds (such as PCBs and VOCs). The analytical method will be ASTM D2974 *Standard Test Methods for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils* (ASTM 2014a).

Particle Density. Particle density, also known as specific gravity, it is a measure of the density of the solids within the sediment matrix. The mean density is usually comparable to the density of quartz (2.6 - 2.7 grams per cubic centimeter [g/cm^3]). Aluminosilicate minerals are comparable whereas iron oxides or heavy metals raise the average density and organic matter lowers it. The analytical method will be ASTM D854 *Standard Test Methods for Specific Gravity of Soil Solids by Water Pycnometer* (ASTM 2014b).

Sulfide/Sulfate. Sulfide/Sulfate is a relative measure of the sulfur content of the sediment and whether the dominant phase is the reduced sulfide or the oxidized sulfate. Under reducing conditions, it is a relative measure of biological activity, particularly of sulfate reducing bacteria. The analytical method will be ASTM D516 *Standard Test Method for Sulfate Ion in Water* (ASTM 2016b).

pH. pH is the negative logarithm of the hydrogen ion activity in a solution, soil, or sediment. Higher pH values represent basic conditions and lower values more acidic. It can be used as a relative measure of composition (presence or absence of alkalinity) or as a measure of biological activity (generally high values under reducing conditions). It is a measure of the acidity of the sediment. The analytical method will be ASTM D4972 *Standard Test Method for pH of Soils* (ASTM 2013).

Saturated Hydraulic Conductivity. Saturated hydraulic conductivity (K) is a quantitative measure of a saturated soil's or sediment's ability to transmit water when subjected to a hydraulic gradient. It determines the ease with which pores of a saturated soil permit water movement. The analytical method will be ASTM D2434 *Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter* (ASTM 2016a).

3.3.5 Schedule

The tentative schedule for execution of these roto-sonic borings is mid- to late-August 2017. The estimated time of completion is approximately four days. This includes deployment, collection, demobilization, and sample processing.

Samples will be submitted for standard TAT, whereby preliminary data should be available in 10 days and final results available in 14 days.

3.4 Sediment Characterization for Engineering Design

A number of analytical methods will be used to collect parameters that are critical for design considerations. However, several analyses require mixed samples or engineering specific analyses and will be collected with a separate effort. Samples will be collected from the surface sediment (OL) and from the underlying marine deposits. The purpose of this sampling is to determine the engineering properties of these sediments in terms of their ability to support placing a cap over the sediment surface. This requires measurements of sediment strength and stability. The samples needed for these analyses will consist of shallow cores collected by hand and processed in the laboratory.

3.4.1 Locations

The locations used for these samples will be the same as used for the roto-sonic borings (Section 3.3) (Figure 3-4). This way, much of the same information collected from the model data collection effort can be applied to the evaluation of the engineering properties of the sediment. Analytical methods will include determination of one-dimensional consolidation; unconfined compressive strength; and consolidated, drained triaxial sheer.

3.4.2 Data Collection

A piston core sampler will be deployed to collect sediment samples at each location. The piston core device will be supplied with a 2.75-in polycarbonate core barrel. The sampling of sediment will follow Jacobs SOP Tech-022 *Sediment Sampling* (Jacobs 2012). The location will be accessed by boat and the location confirmed by RTK-DGPS. A pontoon boat with a moon pool will be use to access the coring locations. The sampler will be deployed through the moon-pool. A water level will be collected by a stadia rod and the water elevation will be documented by a dedicated water level meter placed on a sheet pile near Aerovox. The piston core will be placed on the harbor bottom and the device will be advanced by hand to refusal, usually about 3 to 3.5 ft below the top of the sediment surface. The device will be withdrawn and presence of native material (gray marine sediments) will be confirmed.

Sediments will be collected in 2.5- to 3.0-ft core sections within the polycarbonate barrel. Two cores will be collected per location to ensure that adequate sediment volume is collected. Immediately upon recovery, the ends of the boring liners will be capped with a HDPE core tube cap. The cap will be secured in place using electrical tape. Capped Lexan boring sections will be labeled on the cap or liner in permanent maker to denote:

- Boring ID
- Depth Interval (e.g., 15.0' – 20.0')
- Upper End (marked with an arrow pointing upward)
- Date and Time of Collection
- Presence of PID readings for VOCs (Jacobs 2007)

Should the core be cut to shorter lengths, a cleaned, decontaminated sabre saw or hack saw will be used to cut the tubes. Following the cut, each exposed liner end will be capped and labeled using the process described above. Core sections will be stored in a vertical position until transferred to the on-site field laboratory for analytical subsampling and geological descriptions.

3.4.3 Laboratory Analysis

Upon return to the laboratory, the cores within the polycarbonate barrels will be examined visually. For each stratigraphic component, the core will be assessed to the thickness of each unit. If the stratigraphic section is within the thickness as described for each analytical method below, a type-section from each core will be determined and the most representative section will be selected. Using a clean hacksaw, the polycarbonate barrel and core will be cut to length and re-capped. The whole pre-determined section will then be submitted to the laboratory for analysis using Jacobs SOP Tech 028-*Packing and Shipping of Environmental Samples* (Jacobs 2012).

One Dimensional Consolidation. One Dimensional Consolidation determines the quantifiable changes due to stress on the sediment. More specifically, Karl von Terzaghi's Principle, also known as Terzaghi's theory of one-dimensional consolidation, states that all quantifiable changes in stress to a soil [compression, deformation, shear resistance] are a direct result of a change in effective stress. When soil is loaded undrained, the pore pressures increase. Then, under site conditions, the excess pore pressures dissipate and water leaves the soil, resulting in consolidation settlement. This process takes time, and the rate of settlement decreases over time. For this analysis, a 6- to 7-in section of intact sediment is required. Because of the measurement of surface stress, the OL and the marine deposits are included in the same sample. The sample will be cut in the laboratory and submitted as a whole sample for analysis. The analytical method for this determination is ASTM 2435 *Standard Test Methods for One-Dimensional Consolidation Properties of Soils Using Incremental Loading* (ASTM 2011c).

Unconfined Compressive Strength. Unconfined Compressive Strength measures the maximum axial compressive stress that a right-cylindrical sample of material can withstand under unconfined conditions. The primary purpose of the unconfined compression test is to quickly obtain a measure of compressive strength for those soils that possess sufficient cohesion to permit testing in the unconfined state. This test will be performed on a 6- to 7-in section that consists of marine sediments only. The analytical method will be ASTM D2166 *Standard Test Method for Unconfined Compressive Strength of Cohesive Soil* (ASTM 2016c).

delete both

Consolidated, Drained, Triaxial Sheer. Consolidated, Drained, Triaxial Sheer measures the stress that is applied to a sample of the material being tested in a way that results in stresses along one axis being different from the stresses in perpendicular directions. In this test method, the shear characteristics are measured under drained conditions and are applicable to field conditions where soils have been fully consolidated under the existing normal stresses and the normal stress changes under drained conditions similar to those in the test method. The shear strength determined from the test is commonly used in embankment stability analyses, earth pressure calculations, and foundation design. This test will apply to the OL layer and will analyze a 4-in core section collected from the OL. The analytical method to be used is ASTM D7181 *Method for Consolidated Drained Triaxial Compression Test for Soils* (ASTM 2011b).

3.4.4 Schedule

The work is expected to be completed in mid- to late-August of 2017. It is estimated that approximately 3 days are required for mobilization, collection, demobilization, and sample preparation.

Samples will be submitted for standard TAT, whereby preliminary data should be available in 10 days and final results available in 14 days.

are performed

3.5 Gas Ebullition

Gas Ebullition Test – Draft Procedure

This testing will be performed in two stages. The first stage will be field measurements of in-situ gas ebullition at multiple locations off shore at the Aerovox facility. Once gas production rates are determined, laboratory tests in column(s) containing site sediment with gas bubbled through at the rates measured in the field.

Field measurement of gas ebullition.

Field measurements will be done with the gas sampling apparatus described below over multiple days (i.e., the gas from a sampler will be collected multiple times over a period of days). Gas production will be measured over time and the results reported as a flux based upon the area of the gas collector funnel and sampling time (liters per square meter per day ($l/m^2/d$)). The gas collection systems (Figure 1) is based upon a design by Huttunen et al. (2001) that was modified by Rockne et al. (2011) to provide a more robust sampler valve system with most parts available from a hardware store.

Each collector will consist of a 26 centimeter (cm) (10 inch) external diameter inverted funnel connected to a 1" PVC tube connected to gas-tight ball valve which can be opened for gas collection. Each collector needs to be anchored in place and setup to ensure that the funnel remains at least 10 to 20 cm above the sediment surface. ? The collector works to collect gas bubbles ~~collection~~ within the funnel. As the gas is collected, water beneath the funnel is displaced. As long as the funnel is submerged, the gas is pressurized and when the ball valve is open, the gas will be displaced from the funnel into the collection container by the hydraulic pressure of the water column. The gas is collected in a container of known volume and pressure.

Bubble trap samplers will be set up at 6 to 10 locations beside the Aerovox property ~~(to be selected by ___)~~. Each sampler needs to be anchored in place, and the funnel needs to be submerged throughout the collection process without touching the sediment surface. For locations near the western shore of the channel, the duration of sample collection will be determined by the time where the sampler can remain submerged above the sediment surface. The length of the tubing will depend on the sampler location and the height of the water column during gas collection (the ball valve will need to be above the water surface during transfer of the gas to the sample container).

A steel flange shall be placed on the tube to help the system sink while remaining in a vertical position. A PVC connection with a rubber stopper will be used to facilitate collection of gas samples. Each collector will be attached to a float and anchor.

Sample Time: 4 to 72 hours, ensure variation of sampling times as bubbling may be episodic

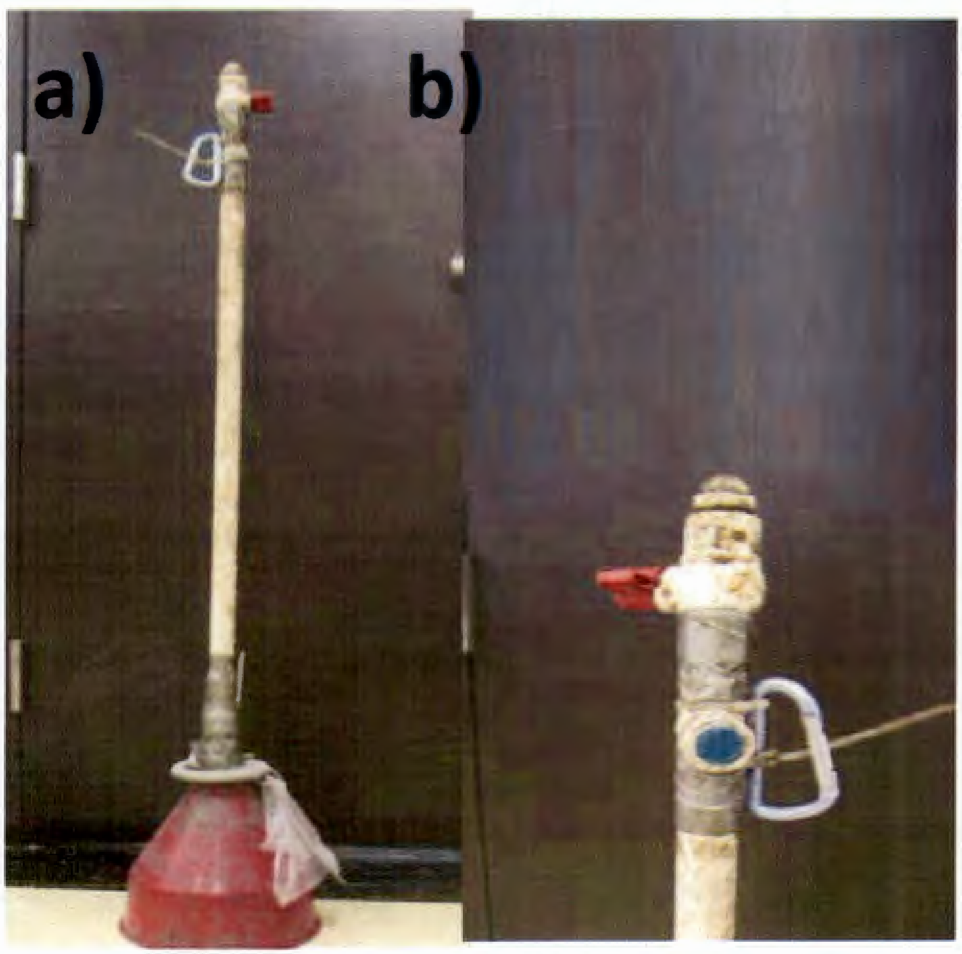
Conditions: test during high winds at least a few times to see if this increases ebullition rates, consider seasonal variations

Locations: test along entire spectrum of depths at the site (results have often previously been shown to be anti-correlated with depth)

Materials:

- - polyethylene funnel (26cm wide mouth and 3 cm wide neck)
- - rubber stopper (to plug neck)
- - stainless steel canula
- - 3 way plastic stopcock with luer fittings)
- - cylindrical plastic-foam fishing net float
- - weights (to keep sampler vertical)
- - 2 buoys with anchors and floating guidelines to make a sample line
    - - glass sample container (consider using 1-liter evacuated BottleVacs)

Figure 1 Gas collector system (a) and b) detail of the collector valve (Rockne, 2011).



Huttunen, J. T., Lappalainen, K. M., Saarijärvi, E., Väisänen, T., and Martikainen, P. J. (2001). "A novel sediment gas sampler and a subsurface gas collector used for measurement of the ebullition of methane and carbon dioxide from a eutrophied lake." Sci. Total Environ., 266(1-3), 153.

Laboratory Testing

{to be further developed from SOW for ERDC}

Goal: examine gas and NAPL transport through saturated fine-grained sediments and potential cap materials

Sediment samples will be collected and sent to the ERDC laboratory in Huntsville, Al. Sediments can either be collected as intact cores, or more practically collected and placed in 5-gallon buckets for shipment. The intent of the sediment sampling is to collect deposits that exist above the native marine clay. Volume of sediment required to be specified by the lab.

At the ERDC lab, the sediment will be packed in plexiglass columns for gas ebullition testing. Gas (air) will be metered in the bottom of the column at rates determined from the field measurements made in step 1 described above. The impact of the bubble flow through the column on the cap materials placed atop the column will be observed.

DNAPL may be spiked into the column to determine whether enhanced NAPL transport occurs with the upward bubble flow. DNAPL movement upward through the sediments and cap may cause testing of additional cap materials such as organoclay that will sorb and prevent NAPL movement.

The number of columns to be tested will be determined based on the variability of sediment materials and depths-to-clay observed during the summer/fall field program. However, it is likely that no more than two columns will be required based on existing field observations.

(intentionally blank)

4.0 Quality Assurance/Quality Control

This section describes the procedures that will ensure that the level of quality is known, maintained, and documented throughout the field programs.

4.1 Field Based Quality Control

Quality control (QC) samples to be collected for the purposes of measuring precision and accuracy of the sampling and analysis process and the approximate frequency of collection are briefly summarized in this section.

4.1.1 Field Duplicates

Field duplicate samples are two samples of the same matrix, which are collected, to the extent possible, at the same time, from the same location, using the same techniques, and are analyzed at the same laboratory. Field duplicates will be handled, containerized, preserved, stored, and transported in the same manner as native samples. Field duplicates will be collected at a frequency of approximately one per 10 samples per matrix. The laboratory will analyze the field duplicate samples independently to provide a measure of sampling variability. Field duplicate results are compared using relative percent difference (RPD) as a measure of precision. In general, RPDs of less than 30 percent indicate acceptable agreement for aqueous and air matrices. RPDs of less than 50 percent indicate acceptable agreement for soil and sediment matrices. Split samples collected for different laboratories (including government QA samples) and/or analyses will also be prepared in this manner.

4.1.2 Field/Equipment Blanks

Field/equipment blanks are samples consisting of reagent (analyte-free) water collected during a sampling event from a final rinse of sampling equipment after the decontamination procedure has been performed. The purpose of equipment blanks is to determine whether the sampling equipment is causing cross contamination of samples. Equipment blanks for sediment samples will be collected at a frequency of one per 20 samples. Where disposable equipment is used, a single equipment blank will be collected to document that the disposable equipment, sample containers, and preservatives are not contaminating the field samples. Concentrations detected in the blanks will be used to determine whether contaminated sampling equipment is contributing to concentrations reported in the samples. In general, if the blank level multiplied by five (10 for common laboratory contaminants) is less than the sample concentration, cross contamination is considered insignificant.

4.1.3 Matrix Spike/Matrix Spike Duplicates (MS/MSD) for Organic Analyses and/or Matrix Spikes (MS) and Laboratory Duplicates for Inorganic Analyses

MS/MSD for organic analyses and MS and laboratory duplicate samples for inorganic analyses are laboratory QC samples used to measure precision and accuracy in addition to identifying matrix interference difficulties with identifying or quantifying target analytes. A known quantity of target analyte is added (spiked) to the sample before preparation and analysis. Samples are prepared in the same manner as the other samples in the batch. Measures of percent recovery and RPD are used to assess precision and accuracy. Spike concentration levels and criteria for recovery and precision are included in the *Quality Assurance Project Plan* (QAPP) (Jacobs 2009b). Field personnel must collect additional sample volume for laboratory QC samples at a frequency of one pair per 20 samples and designate these as such on the COC.

4.1.4 Trip Blanks

Trip blanks consist of laboratory-grade distilled and/or deionized water collected in two 40-ml glass vials with Teflon seals. They are used to detect contamination that may be introduced during sample handling and transport. These QC samples are prepared by the laboratory, shipped to the field, and returned to the laboratory unopened. A trip blank will be included with each sample shipment cooler sent to the laboratory for VOC analyses. Trip blank results are evaluated in the same manner as equipment blanks.

4.1.5 Temperature Blanks

Temperature blanks in each cooler will not be required. Many of the analyses are physical parameters and do not require refrigeration. However, for the sediment samples analyzed for chemical components, a temperature blanks will be added to each cooler. For the water samples, the temperature of each sample container will be checked upon receipt at the laboratory by either an infrared gun or a digital thermometer, and the temperature recorded on the cooler receipt form. Elevated (greater than 6 degrees Celsius (°C)) temperatures will be considered during the validation process to determine the effect, if any, to reported data.

4.1.6 Field Instrument Quality Control

Procedures for use and calibration of field monitoring instruments will follow manufacturer's guidelines and site-specific procedures discussed below. The water quality instrument used in the groundwater flux investigation will require daily calibration following Jacobs SOP Tech-011 *Field Measurements Using the YSI 6820 and 6920 Water Quality Meter* (Jacobs 2012). The following will be implemented to calibrate and document the use of field equipment:

1) A list is established to include the measuring and testing devices (field equipment) to be calibrated and the frequency of calibration of this equipment. The method and interval of calibration shall be based on the type of equipment, stability characteristics, required accuracy, and other conditions affecting measurement control.
2) The measuring and testing equipment used are of the proper range, type, and accuracy for the test being performed.
3) Calibration for the equipment will be kept in the site logbook or on field log sheets and include at least the following information:
    - name of equipment,

- equipment serial and/or identification number,
- frequency of calibration,
- date of last calibration,
- name of individual performing last calibration, and
- due date for next calibration.

4) Field equipment will be marked with calibration due dates when possible. When this marking is not possible, alternative methods of tracing the equipment to its calibration date (such as serialization) will be employed.

5) Field equipment will be calibrated in accordance with the requirements of this section. Prior to field use, each instrument will be calibrated and its documentation, which substantiates the calibration, will be made available.

6) Systems are developed and maintained for issuance, collection, and return of measuring and field equipment. This system will provide for the identification of personnel withdrawing equipment, methods for issuing equipment, and methods for the collection and/or return of equipment at prescribed calibration times or as otherwise required.

7) Methods will be employed to ensure proper handling, storage, and care of the test equipment in order to maintain its required accuracy.

8) Field equipment used to screen samples and/or monitor health and safety parameters will be calibrated at a minimum of once at the beginning and once at the end of each day of use.

9) Calibration activities will be performed in accordance with written manufacturer's instructions, or with EPA methods, where they exist. Calibration will be documented in the field logbook or on appropriate log sheets.

If field equipment is damaged and/or there are indications that the equipment may not be performing properly, the equipment will be removed from service until it is repaired or replaced.

4.2 Sample Handling and Custody Procedures

Sediment samples for chemical analysis and water samples will be packed on the boat and placed on ice prior to storage in a refrigerator prior to packing and shipping. Whole sediment samples that will be sent for physical characteristics will not be preserved, but will be processed as quickly as possible and shipped as early as possible. Containers for chemical analyses will be purchased or provided by the laboratory and certified as contaminant-free in accordance with *EPA Specifications and Guidance for Contaminant–Free Sample Containers* (EPA 1992). Sample containers, preservation requirements, and laboratory holding times for chemical analyses are summarized in Table 3-2. Preservatives, as required by the analytical methods, will be provided to the field personnel by the laboratory.

Samples for chemical analysis will be stored on ice from the time of sample collection. Samples for laboratory analysis will be shipped via courier or by overnight delivery service for same day or next day delivery in waterproof coolers following Jacobs SOP Tech-028, *Packing and Shipping of Environmental Samples*

(Jacobs 2012). In general, the samples taken for this project will be considered low-level or environmental samples for packaging and shipping purposes.

To maintain and document sample possession, COC procedures will be implemented. Personnel collecting samples are responsible for the care and integrity of samples until they are properly transferred or dispatched. Therefore, the number of people handling a sample will be kept to a minimum.

COC records will be completed by the sampler and shall accompany the samples at all times. An example COC form is included in Appendix C. Additional information about the COC is presented in the QAPP (Jacobs 2009b).

4.3 Decontamination

All equipment designated for re-use will be decontaminated according Jacobs SOP Tech-036 *Equipment Decontamination* (Jacobs 2012). Sampling equipment will be decontaminated at the site location using harbor water for rinsing. These will include the polycarbonate core barrels, gutters, drive points, stadia rods or any other equipment that has come in contact with contaminated sediment. Any excess sample collected on the boat will be discharged back into the harbor. Waste generated during the laboratory processing of samples will be added to the waste stream of the remedial operations and shipped to an off-site facility as hazardous waste.

4.4 Quality Management and Nonconformance

QA procedures and requirements will be followed as described in the QAPP (Jacobs 2009b) to ensure that all procedures are followed. Nonconformance issues will be identified and documented, as required in Jacobs SOP QA-007, *Control of Nonconformance Items and Services* (Jacobs 2009b). This procedure will ensure that the nonconforming material is segregated and the appropriate disposition is implemented. Any modifications, repairs, rework, acceptance or replacement of materials will be tracked, documented, and verified by the QA or management staff. All personnel involved with the implementation of this work plan shall read and understand the scope of the project, and conduct work activities pursuant to those contained in the QAPP.

5.0 Documentation and Reporting

Documentation of field activities will be kept in logbooks, in photographs and in daily reports. Detailed, bound, weatherproof field logbooks with numbered pages shall be maintained by the field representative to record information related to sampling or field activities. This information will be written in ink in accordance with Jacobs SOP Tech-035, *Field Logbook* (Jacobs 2012), and will include the following:

- date and time of site visit,
- climatic conditions,
- key personnel on-site,
- health and safety levels of protection,
- description of field activities, including approved work changes and/or deviations from approved project plans,
- comments to/from government party representatives,
- sampling location and identification,
- sampling sequence and time of each sample collection,
- types of sample containers used and sample identification numbers,
- parameters requested for analysis,
- field observations during sampling event, including a visual description of sample (color, odor, etc.),
- name of sample collector(s),
- QA/QC data for field instruments,
- problems encountered,
- description of sampling equipment used, including trade names, model number, diameters, material composition, etc., and
- description of instrument calibration procedures and results.

5.1 Sample Identification

Samples will be uniquely identified to document their origin and purpose. Samples will be labeled with the site name, date and time collected and the analysis required. Chemical sample labels will also include the preservative (if applicable). The sample identifier will consist of an alphanumeric code, which identifies the sample type, location, depth, and QC designation.

A unique sample identification code will be required for every sample. In general, this matrix-specific protocol follows:

Matrix	Code
Sediment	S-Loc-MMDDYY-Depth
Groundwater	GW-Loc-MMDDYY--Depth

Where

MM = month of sample collection (2 digit)
DD = day of sample collection (2 digit)
YY = year of sample collection (2 digit)
S = sediment prefix (1 digit)
GW = groundwater prefix (2 digits)
Loc = sample location ID
top depth = numeric top depth of sample in feet (') and/or inches (")(1 or 2 digits)
bottom depth = numeric bottom depth of sample in feet (') and/or inches (")(1 or 2 digits)
For example a groundwater sample from a drivepoint in the Harbor would be designated as:

- GW-ADP-LL-01-MMDDYY-Depth'

Where: ADP = Aerovox Drive Point
LL = East to West Transect
01 = North to South Column

A sediment sample collected from a piston core would be:

- S-AS-LL-02-MMDDYY-Upper Depth'-Lower Depth'

Where: AS = Aerovox Sediment

LL = East to West Transect
02 = North to South Column

A sediment sample from a sonic boring would be:

- S-ASB-36-MMDDYY-Upper Depth'-Lower Depth'

Where: ASB = Aerovox Sonic Boring

36 = Boring Number

QC prefix will be correlated with the date and sequential identification number. Jacobs will identify field QC samples as outlined below.

Matrix	Code
FD	"Sample Duplicate" FD
Equipment Blank	EB-MMDDYY-EB Seq. No.
Trip Blank	TB-MMDDYY-TB Seq. No.

Where

Sample ID = appropriate field Sample ID described above
QA = QA Split suffix
FD = field duplicate suffix
EB = equipment blank prefix (all matrices excluding air)
TB = trip blank prefix
MM = month of sample collection
DD = day of sample collection
YY = year of sample collection
EB seq. no. = sequential number (01, 02, etc.) assigned to each equipment blank sample during a sample collection day. Sequence number reset to 01 at start of each sample collection day.
TB seq. no. = sequential number (01, 02, etc.) assigned to each trip blank sample during a sample collection day. Sequence number reset to 01 at start of each sample collection day.

5.2 Reporting

Data generated from verification sample collection and PCB analyses will be provided in a Pre-Design Study Data Report. This report will also include a brief description of field procedures used during the study, as well as revised maps and cross sections, as appropriate. Adequacy of the data for design purposes will also be addressed.

Analytical data from the samples sent for offsite laboratory analysis will require data validation. Data validation will be completed by the Jacobs' Project Chemist. All validated analytical data and data validation reports will be included in the after-action report. Data validation will be completed in accordance with the SOPs outlined in the FSP (Jacobs, 2012). Analytical data generated from IA will not require validation.

(intentionally blank)

6.0 Safety Procedures

All fieldwork will follow the guidelines in *the 2007 Site Specific Safety and Health Plan, New Bedford Harbor Superfund Site* (Jacobs 2007). All personnel conducting fieldwork will report to the morning tailgate and will prepare a Safe Plan of Action (SPA) prior to engagement of daily activities. The personnel will conduct the investigation with the assumption that they will come in contact with contaminated sediments. This requires personnel to don modified Level D personal protection equipment (PPE) including hard hats, safety glasses, steel toe boots, boot covers, gloves, and Tyvek suits. The personnel will also require personal flotation devices (PFDs) when working on the water.

The personnel will carry a calibrated PID for VOCs to ensure that the VOC concentrations in the work area are safe within the breathing zone (Jacobs 2007). The PID will be calibrated by qualified Health and Safety personnel each morning.

A 'chirper' will be onboard the pontoon boat or sonic rig to alert workers of any hydrogen sulfide gas.

(intentionally blank)

7.0 Unanticipated Discovery of Cultural Remains

Should cultural remains be found during the course of this investigation, the field team will comply with *Plans and Procedures Addressing Unanticipated Discoveries of Cultural Resources and Human Remains* (Jacobs 2010a). Should the field team encounter cultural remains, they are to stop work immediately if they observe any indications of the presence of cultural materials, animal bone, or possibly human bone, contact the site manager (or the Jacobs Project Manager if the site manager is not available) as soon as possible, comply with unanticipated discovery procedures, and treat human remains with dignity and respect.

(intentionally blank)

8.0 References

AECOM Technical Services, Inc. 2015 (September). *Phase II Comprehensive Site Assessment*. Prepared for AVX Corporation, Myrtle Beach, SC.

ASTM (American Society of Testing and Materials). 2017. *Standard Test Method for Density of Soil In Place by the Drive-Cylinder Method.* ASTM D2937

______. 2016a. *Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter.* ASTM D 2434

______. 2016b. *Standard Test Method for Sulfate Ion in Water.* ASTM D 516

______. 2016c. *Standard Test Method for Unconfined Compressive Strength of Cohesive Soil.* ASTM D2166

______. 2014a (November). *Standard Test Methods for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils.* ASTM D2974

______. 2014b. *Standard Test Methods for Specific Gravity of Soil Solids by Water Pycnometer.* ASTM D854

______. 2013. *Standard Test Method for pH of Soils.* ASTM D 4972

______. 2011a. *Standard Practice for Classification of Soils for Engineering Purposes.* ASTM 2487

______. 2011b. *Method for Consolidated Drained Triaxial Compression Test for Soils.* ASTM D7181

______. 2011c. *Standard Test Methods for One-Dimensional Consolidation Properties of Soils Using Incremental Loading.* ASTM D2435

______. 2010a (July). *Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass.* ASTM D2216

______. 2010b, *Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.* ASTM D4318

______. 2007. *Standard Test Method for Particle-size Analysis of Soils.* ASTM D422

BBL (Blasland, Bouck, & Lee Inc.). 1998 (August). Engineering Evaluation/Cost Analysis. MAD062319777

ENSR (ENSR Corp.). 2006 (March). *Aerovox Facility-Conceptual Site Model.* ENSR 09000-350-755

EPA (U.S. Environmental Protection Agency). 2004 (September). *Site Characterization Technologies for NAPL Investigation.* EPA 542-R-04-017.

_____. 1992 (December). *EPA Specifications and Guidance for Contaminant–Free Sample Containers.* EPA540/R-93/051.

Gushue, J.J. and R.S. Cummings. 1984. *On-Site Containment of PCB-Contaminated Soils at Aerovox, Inc., New Bedford, Massachusetts.* SDMS 248154.

Huttunen, J. T., Lappalainen, K. M., Saarijärvi, E., Väisänen, T., and Martikainen, P. J. (2001). *A Novel Sediment Gas Sampler and a Subsurface Gas Collector Used for Measurement of the Ebullition of Methane and Carbon Dioxide from a Eutrophied Lake.* Sci. Total Environ., 266(1-3), 153

Jacobs (Jacobs Engineering Group). 2017 (March). *Final Technical Memorandum Summary of Findings 2016 Investigation Update – Aerovox Near Shore Area, New Bedford, Massachusetts*. ACE-J23-35BG1001-M17-0026.

_____. 2016 (January). *Lower Harbor Dredge Work Plan*. ACE-J23-35BG1001-M1-0024.

_____. 2012 (April). *Field Sampling Plan, New Bedford Harbor Superfund Site, New Bedford, Massachusetts*. ACE-J23-35BG0706-M3-0001.

_____. 2011 (March). *2010 Dredge Season Data Submittal, New Bedford Harbor Remedial Action*. ACE-J23-35BG0706-M17-0002.

_____. 2010a (September). *Plans and Procedures Addressing Unanticipated Discoveries of Cultural Resources and Human Remains*. ACE-J23-35BG0801-M3-0002.

_____. 2010b (February). *2009 Dredge Season Data Submittal, New Bedford Harbor Remedial Action*. ACE-J23-35BG0801-M17-0001.

_____. 2009a (May). *2008 Dredge Season Data Submittal, New Bedford Harbor Remedial Action*. ACE-J23-35BG0702-M17-0001

_____. 2009b (March). *Quality Assurance Project Plan New Bedford Harbor Superfund Site*. ACE-J23-35BG0702-M3-0009.

_____. 2007 (August). *2007 Site-Specific Safety and Health Plan, New Bedford Harbor Superfund Site, New Bedford, Massachusetts*. ACE-J23-35BG0101-M3-0007.

Versar (Versar Inc.). 1981 (June). *Report on Inspection to Determine Compliance with the Federal PCB Disposal and Marking Regulations*. Report prepared for U.S. Environmental Protection Agency, Boston, MA.

Figures

Legend

N

0 2 Miles

1:100,000

Basemap Reference: © 2009 Bing Maps Aerial

JACOBS

Site Location Map

New Bedford Harbor Superfund Site

NAME: jpiccuito Date: 2/26/2013

Figure 1-1

Path: Y:\NBH\Projects\35BG0708\20130225\ArcGIS\NBH_Site_Map_Final.mxd

Legend

N

0 600 Feet

1:7,200

Aerial Photography MASSGIS 2009

JACOBS

Upper Harbor Showing Former Aerovox Property Location

New Bedford Harbor Superfund Site

Figure 2-1

Legend

- ⊙ Aerovox Boring Location
- ⟷ Aerovox Cross Section Location
- — Sheet Pile Location

Aerial Photography MASSGIS 2014

0 50 100 Feet

1:1,200

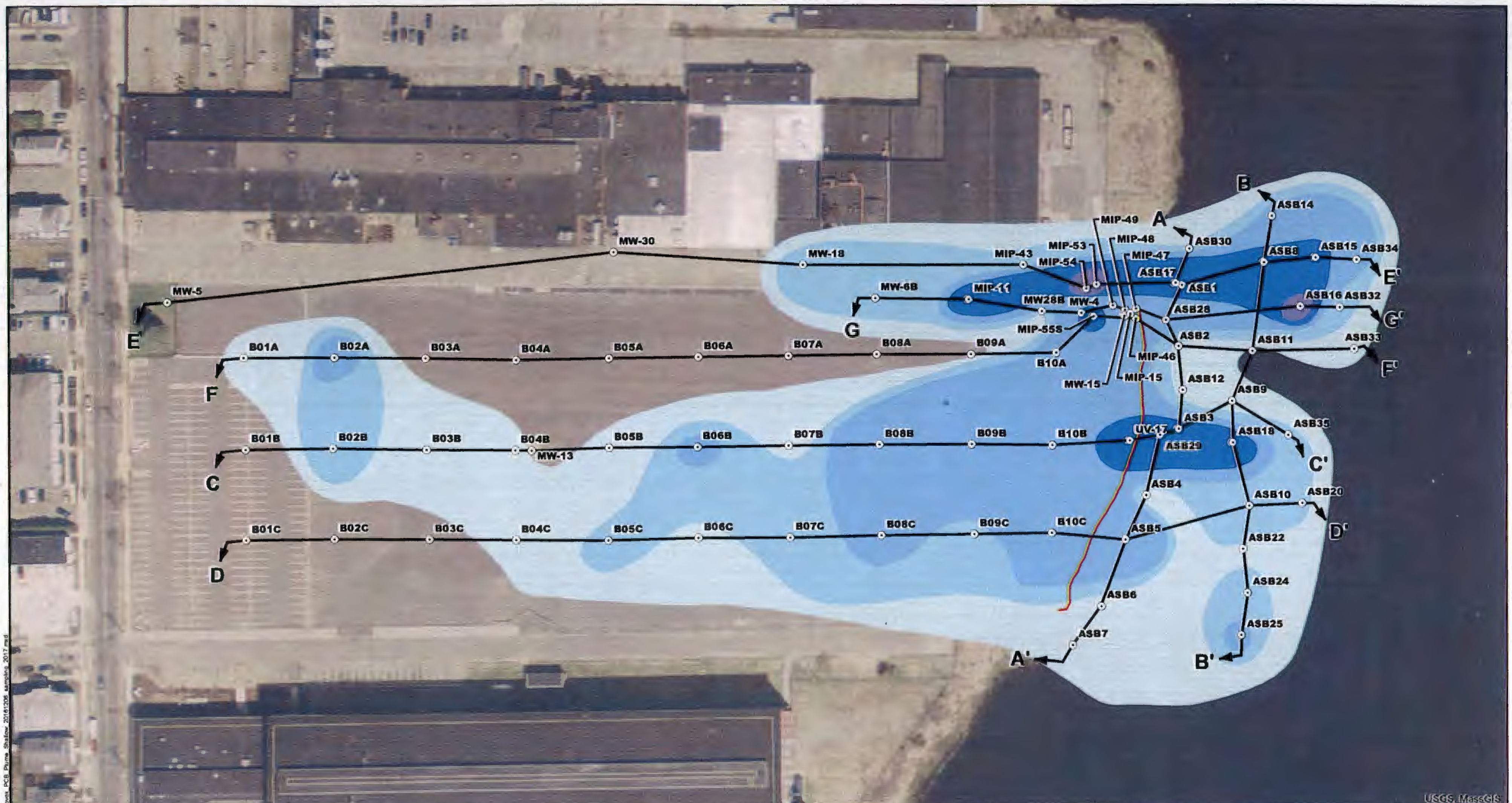
JACOBS

Former Aerovox Site Area

New Bedford Harbor Superfund Site

Date: 7/10/2017

Figure 2-2



Legend

⊙ Aerovox Boring Location

Aerovox Cross Section Location

Sheet Pile Location

Total PCB

Concentration (mg/kg)

- 1-10
- 10-100
- 100-1,000
- 1,000-10,000
- >10,000

Shallow Soils/Sediments
Aerovox Site: 0-13 ft bgs
New Bedford Harbor: 0-7 ft bgs

Aerial Photography MASSGIS 2014

N

0 50 100 Feet

1:1,200

JACOBS

PCB Distribution for Former Aerovox Site Area Shallow Soils/Sediments

New Bedford Harbor Superfund Site

Date: 7/10/2017

Figure 2-3

Legend

Aerovox Boring Location

DNAPL Data Gap Sediment Location

DRAFT

N

0 25 50

Feet 1:600

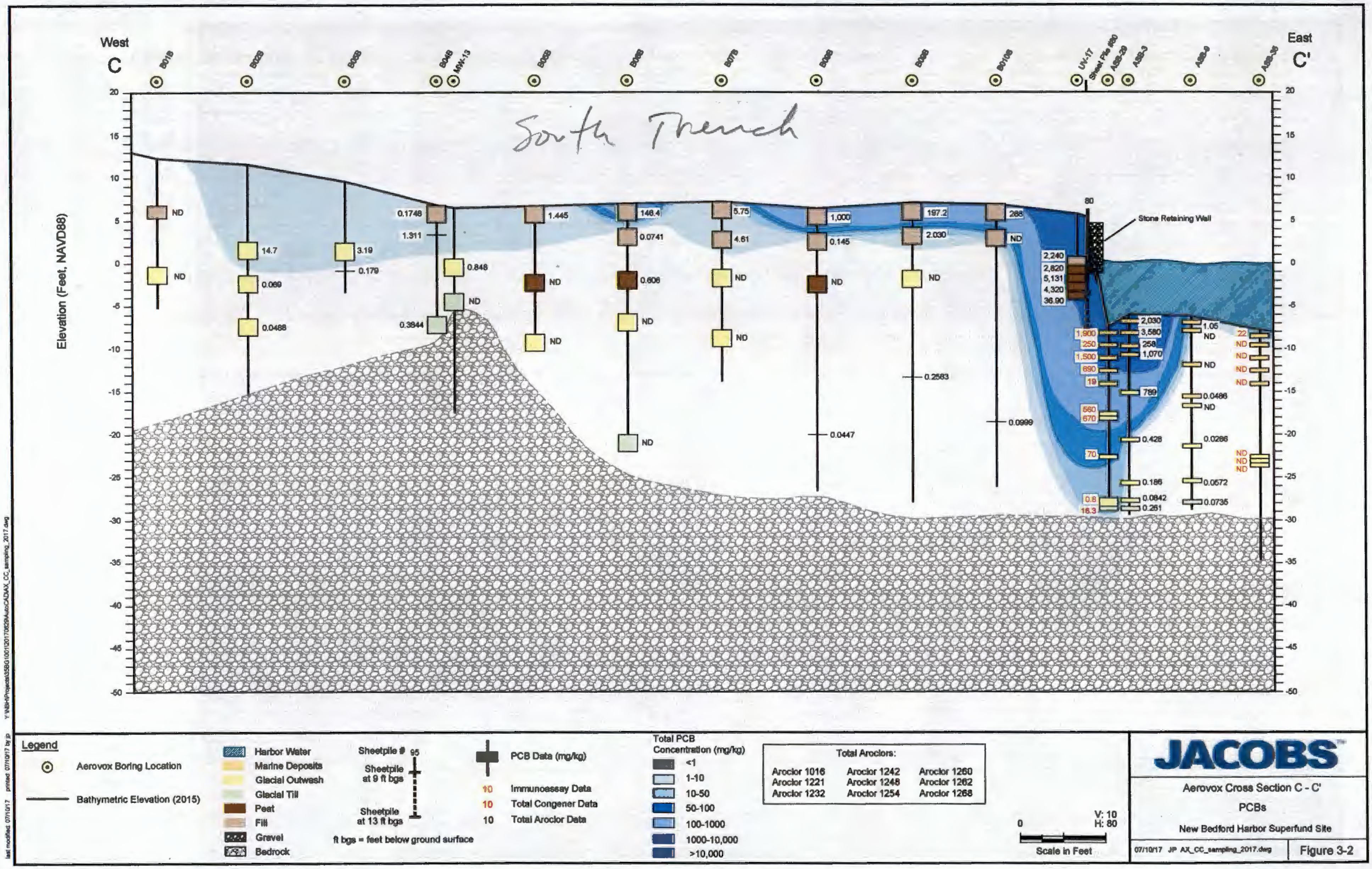
JACOBS

Aerovox DNAPL Data Gap Sampling Locations

New Bedford Harbor Superfund Site

Date: 7/10/2017

Figure 3-1



West
C
East
C'
B01B
B02B
B03B
B04B
MW-13
B05B
B06B
B07B
B08B
B09B
B010B
UV-17
Sheet Pile #80
ASB-29
ASB-3
ASB-9
ASB-35
South Trench
Elevation (Feet, NAVD88)
Stone Retaining Wall
ND
14.7
0.069
0.0488
3.19
0.179
0.1748
1.311
0.3844
0.848
1.445
146.4
0.0741
0.606
5.75
4.61
1,000
0.145
197.2
2,030
0.2583
288
0.0447
0.0999
80
2,240
2,820
5,131
4,320
36.90
1,900
250
1,500
690
19
560
670
70
0.8
16.3
2,030
3,580
258
1,070
789
0.428
0.186
0.0842
0.261
1.05
0.0486
0.0286
0.0572
0.0735
22
Legend
Aerovox Boring Location
Bathymetric Elevation (2015)
Harbor Water
Marine Deposits
Glacial Outwash
Glacial Till
Peat
Fill
Gravel
Bedrock
Sheetpile # 95
Sheetpile at 9 ft bgs
Sheetpile at 13 ft bgs
ft bgs = feet below ground surface
PCB Data (mg/kg)
10 Immunoassay Data
10 Total Congener Data
10 Total Aroclor Data
Total PCB Concentration (mg/kg)
<1
1-10
10-50
50-100
100-1000
1000-10,000
>10,000
Total Aroclors:
Aroclor 1016
Aroclor 1221
Aroclor 1232
Aroclor 1242
Aroclor 1248
Aroclor 1254
Aroclor 1260
Aroclor 1262
Aroclor 1268
0
V: 10
H: 80
Scale in Feet
JACOBS
Aerovox Cross Section C - C'
PCBs
New Bedford Harbor Superfund Site
07/10/17 JP AX_CC_sampling_2017.dwg
Figure 3-2

Legend

Aerovox Boring Location

Drivepoint Location

DRAFT

0 25 50 Feet 1:600

N

JACOBS

Aerovox Drivepoint Locations

New Bedford Harbor Superfund Site

Date: 7/10/2017

Figure 3-3

Legend

- Aerovox Boring Location
- Aerovox New Boring Location

DRAFT

N

0 25 50 Feet 1:600

JACOBS

Aerovox Borehole Locations

New Bedford Harbor Superfund Site

Date: 7/6/2017

Figure 3-4

Tables

Table 3-1
Aerovox DNAPL Data Gap Locations

Location	Easting (X)[1]	Northing (Y)[1]
AS-AA-05	815679.85	2707170.03
AS-AA-06	815735.57	2707170.21
AS-BB-08	815842.19	2707121.96
AS-CC-09	815894.26	2707068.99
AS-DD-09	815892.51	2707014.67
AS-FF-08	815841.90	2706913.04
AS-GG-08	815842.48	2706859.57
AS-II-07	815788.14	2706753.51
AS-JJ-07	815790.47	2706703.54
AS-KK-07	815790.47	2706650.07
AS-LL-02	815532.98	2706594.39
AS-LL-04	815634.29	2706594.28
AS-LL-06	815738.42	2706594.58

[1]NAD83, Mass State Plane (ft)

Table 3-2
Sample Containers, Preservation, and Laboratory Holding Times

Analysis	Matrix/ Media	Lab Method	Sample Container	Preservative	Holding Time[1]
PCBs	Aqueous	SW8082B	2 x 1 L. Glass	4°C	7 days to extraction, 40 days to analysis,
	Solid	SW4020, SW8082B	8 oz. Glass for each laboratory if different labs are used for different methods	4°C	14 days to extraction, 40 days to analysis, 1 year if frozen
Metals	Aqueous	SW6010C/ SW7470B	250 milliliters (mL) high density polyethylene (HDPE)	4°C, HNO_3 pH<2	Hg 28 days, other metals 6 months
	Solid	SW6010C/ SW7471A	4 oz. Glass	4°C	Hg 28 days, other metals 6 months
VOCs	Solid	SW8260C	3 x 40 mL volatile organic analyses (VOA)	4°C 2 vials $NaHSO_4$ 1 vial MeOH	14 days to analysis
	Aqueous	SW8260C	3 x 40 mL VOAs	4°C, HCL pH<2	14 days to analysis
Methane	Aqueous	RSK 175	3 x 40mL VOCs	4°C	14 days to analysis
Sulfide	Aqueous	SW9030B	500 mL plastic	4°C, NaOH, pH>12 Zn Acetate	7 days to analysis
Sulfate-Chloride-Nitrate	Aqueous	E300.0	500 mL plastic	4°C	Sulfate, Chloride: 28 days to analysis Nitrate: 48 hours to analysis
Total Alkalinity	Aqueous	E310.1	500 mL plastic	4°C	14 days to analysis
Dissolved Organic Carbon	Aqueous	E415.1	500 mL plastic	4°C	28 days to analysis
Bulk Density	Solid	ASTM D2937	Plastic Bag	None	None
Particle Size Analysis	Solid	ASTM D422	Plastic Bag	None	None
Atterburg Limits	Solid	ASTM D4318	Plastic Bag	None	None
Soil Classification	Solid	ASTM D2487	Plastic Bag	None	None
Soil Moisture	Solid	ASTM D2216	Plastic Bag	None	None
Total Carbon	Solid	ASTM D2974	Plastic Bag	None	None
Particle Density	Solid	ASTM D854	Plastic Bag	None	None
Sulfate-Sulfide	Solid	SW9030B	4 oz. Glass jar	4°C	14 days to analysis
pH	Solid	ASTM D4972	Plastic Bag	None	None
Saturated Hydraulic Conductivity	Solid	ASTM D2434	Plastic Bag	None	None
One-Dimensional Consolidation	Solid	ASTM D2435	Plastic Bag	None	None
Unconfined Compressive Strength	Solid	ASTM D2166	Plastic Bag	None	None
Consolidated, Drained, Triaxial Sheer	Solid	ASTM D7181	Plastic Bag	None	None

Notes: [1]Holding times are from date of collection.

[2]Sediment samples for multiple PCB analyses (i.e., congeners and homologue groups) may be combined into a single container (i.e., one 8-oz. jar)

Table 3-3
Aerovox Drive Point Locations

Location	Easting (X)[1]	Northing (Y)[1]
ADP-BB-05	815679.73	2707118.74
ADP-BB-06	815735.54	2707120.21
ADP-BB-07	815789.60	2707120.79
ADP-BB-08	815842.19	2707121.96
ADP-CC-04	815631.52	2707065.57
ADP-CC-05	815684.41	2707065.86
ADP-CC-06	815736.42	2707067.32
ADP-CC-07	815788.24	2707068.41
ADP-CC-08	815841.10	2707068.99
ADP-CC-09	815894.26	2707068.99
ADP-DD-04	815631.23	2707011.51
ADP-DD-05	815684.41	2707014.14
ADP-DD-06	815736.13	2707013.85
ADP-DD-07	815788.48	2707014.29
ADP-DD-08	815840.52	2707015.25
ADP-DD-09	815892.51	2707014.67
ADP-EE-04	815631.82	2706960.67
ADP-EE-05	815683.53	2706959.79
ADP-EE-06	815736.71	2706960.67
ADP-EE-07	815787.95	2706962.10
ADP-EE-08	815841.40	2706963.85
ADP-EE-09	815893.68	2706963.85
ADP-FF-04	815630.94	2706907.78
ADP-FF-05	815681.20	2706908.37
ADP-FF-06	815736.42	2706909.24
ADP-FF-07	815789.31	2706911.29
ADP-FF-08	815841.90	2706913.04
ADP-GG-04	815632.11	2706857.24
ADP-GG-05	815684.12	2706857.82
ADP-GG-06	815738.17	2706857.53
ADP-GG-07	815789.01	2706858.99
ADP-GG-08	815842.48	2706859.57
ADP-HH-04	815633.28	2706802.89
ADP-HH-05	815682.95	2706804.64
ADP-HH-06	815736.13	2706804.35
ADP-HH-07	815789.31	2706805.23
ADP-HH-08	815841.31	2706805.23
ADP-II-03	815581.27	2706750.29
ADP-II-04	815632.98	2706751.17
ADP-II-05	815684.12	2706752.05
ADP-II-06	815736.91	2706752.10
ADP-II-07	815788.14	2706753.51
ADP-JJ-03	815582.73	2706700.33
ADP-JJ-04	815632.98	2706698.87
ADP-JJ-05	815683.83	2706698.87
ADP-JJ-06	815737.00	2706700.91
ADP-JJ-07	815790.47	2706703.54
ADP-KK-02	815529.47	2706646.38
ADP-KK-03	815582.63	2706647.25
ADP-KK-04	815634.74	2706647.15
ADP-KK-05	815684.41	2706647.74
ADP-KK-06	815738.46	2706648.32
ADP-KK-07	815790.47	2706650.07
ADP-LL-01	815481.28	2706592.64
ADP-LL-02	815532.98	2706594.39

Yellow highlight indicates location of passive sampler

[1]NAD83, Mass State Plane (ft)

Table 3-4
Aerovox Sonic Boring Locations

Boring	Easting (X)	Northing (Y)
ASB-36	815828.98	2707088.13
ASB-37	815725.26	2706935.99
ASB-38	815627.53	2706778.06

[1]NAD83, Mass State Plane (ft)

Appendix A
Immunoassay Lab Process Outline

1. **Portion approximately 40 g of sample into drying pan** (~1.5 hours for 50 samples)
    a. Log sample IDs into tracking log and assign/cross-reference to pan #s.
    b. Pre-label drying pans with pan #s and log empty pan weight.
    c. Use disposable plastic spoon to transfer approximately 35-40 g of wet sample from sample jar into aluminum pans, Note: for low solids samples such as peat the entire 4 oz. sample may be required (approx. 100 g). Larger drying tins may be required to ensure complete drying.
    d. Log total (pan + wet sediment) wet weight into tracking sheet.
    e. Place pans in oven, set oven to 100^{0} C (change gloves after each sample).
    f. Power on the oven prior to leaving at the end of the day. Samples should dry for a minimum of 12 hours.

2. **Break-up and transfer dried samples into weigh boats** (~5.5 hours for 50 samples)
    a. Pre-label plastic weigh boats and extraction jars with pan #s.
    b. Remove dried sediment from oven.
    c. Record dry weights in the tracking log.
    d. Use vendor supplied Wooden Tongue Depressors (disposable), Stainless Steel Spatulas, and or Stainless Steel Mortar & Pestles (properly deconned per TECH-036 after each use) to break up dried sediment as fine as possible.
    e. Add 10 g of sample into weigh boats using the lab scale to check for accuracy – sample should be within +/- 0.1 g.
    f. Transfer 10 g of sample from plastic weigh boat into extraction jar – transfer slowly to avoid spilling.

3. **Methanol extraction** (~1 hour for 50 samples)
    a. Pour 20 mL of vendor provided methanol into the graduated measuring cup.
    b. Transfer methanol into each extraction jar and immediately recap.
    c. Once all extraction jars have received methanol, vigorously agitate jars for 1 minute.
    d. Set aside for settling.
    e. Wait 30 minutes until sediment has settled and a visible layer of solvent has developed on top of the sediment layer.

4. **Filter extract** (~1 hours for 50 samples)
    a. Pre-label filter tops with pan #s for all samples.
    b. Use the bulb pipette to withdraw extract – withdraw very slowly to avoid sucking up sediment.
    c. Transfer at least half a bulb of extract into a filter bottom.
    d. Insert filter top and slowly press down until the top snaps into the bottom – you need to press hard until you hear an audible click.

e. Set aside.

Note: Continue onto step 5 prior to storage of extracted samples, the filters are not air tight and evaporation or leakage may occur over time effecting analytical results.

5. **Initial dilution (25 µL extract into 25mL diluent)** (~1.5 hours for 50 samples)
    a. Pre-label the provided glass diluent vials with pan #s for all samples.
    b. Remove filter top caps and use the provided, disposable fixed volume pipettor (25 µL) and pipette tips to withdraw filtered extract.
    c. Pipette 25 µL of filtered extract directly into diluent vials.
    d. Screw cap tightly onto diluent vials and mix by inverting several times.
    e. Depending on time available, either place diluted samples into the fridge for later analysis or proceed to the second dilution and/or analysis.

Note: Extracted samples may be stored in a laboratory refrigerator for up to 40 days prior to analysis. This method has a quantitation range of 0.5 to 10 ppb for the liquid extract, this equates to a range of 1.0 to 20 ppm in soils. If the analyst knows the anticipated range or a desired quantitation range is established serial dilutions may be performed to prevent the need for re-analysis. Table 1 will aid in the selection of required dilutions.

Dilution Factor	Quantitation Range in Soil (ppm)
1	1-20
5	5-100
10	10-200
50	50-1000
100	100-2000

6. **Additional dilution if necessary** (~1 hour for 50 samples)
    Utilizing the Adjustable Volume Pipet, extract and diluent volumes must be between 100-1000 µL, otherwise volumes dispensed may not be accurate.
    a. Pre-label caps of small glass vials with pan #s and dilution factor for all samples.
    b. Set the adjustable volume pipettor to the diluent volume required and attach a 1000 µL pipette tip.
    c. Pipette appropriate volume Sample Diluent (provided) into each vial
    d. Set the adjustable volume pipettor to and the required extract volume and attach a new 1000 µL pipette tip.
    e. Pipette of the appropriate volume of sample extract from the initial dilution vials (from Step 5) directly into the fluid in each corresponding small vial – change pipette tips between samples.
    f. If further dilution is required follow steps a-e utilizing the 10x diluted extract.

g. Once complete, all samples are ready for analysis – either place in fridge or proceed with analysis.

Secondary Dilution

Dilution Factor	µL of Extract	µL of Diluent
1X	200	0
5X	200	800
10X	100	900

If a dilution factor greater than 10 is required, a 10x diluted extract solution should be prepared first, the 10x solution is utilized to prepare further dilutions.

Tertiary Dilution

Dilution Factor	µL of 10x Diluted Extract	µL of Diluent
50X	200	800
100X	100	900
Dilution Factor	µL of 100x Diluted Extract	µL of Diluent
200X	500	500

7. **Set up for analysis** (~0.5 hours for 50 samples) Steps 7-9 must be completed within the time limits specified.
   a. Remove test kits from fridge and allow at least one hour for reagents to come to room temperature.
   b. Turn on the RPA-II analyzer and printer allowing it to warm up for at least 30 minutes prior to use.
   c. Label five, 25 mL Combitips as follows:
      i. Conjugate
      ii. Particles
      iii. Wash
      iv. Color
      v. Stop

      Note that combitips may be cleaned and reused as long as they are used to dispense the same reagent/solution.
   d. Pre-label the top portions of ten clean plastic test tubes and one plastic tube for each sample as follows:
      i. Cal **1 Rep 1**
      ii. Cal **1 Rep 2**
      iii. Cal **2 Rep 1**
      iv. Cal **2 Rep 2**

v. Cal **3 Rep 1**
vi. Cal **3 Rep 2**
vii. Cal **4 Rep 1**
viii. Cal **4 Rep 2**
ix. Control
x. Blank
xi. Sample 1 (Pan # and dilution factor)
xii. Sample 2, etc...

8. **Performing the test** (~2.5 hours for 50 samples)
   a. Separate the upper rack (with numbered holes) from the magnetic base.
   b. Place labeled test tubes into the rack.
   c. Set the adjustable volume pipettor to 200 µL and attach a clean 1000 µL pipette tip.
   d. Add 200 µL of standards, control or sample to the bottom of their corresponding test tubes, use the table below to prepare the calibration standards, Rep 1 & 2 of each "Cal" are prepared identically in separate tubes. **Nothing is added to the Blank tube until step f**.

Add 200 µL of this solution	To prepare
Diluent/Zero Standard; 0.0 ppb PCB	Cal 1
Standard 1 0.25 ppb PCB	Cal 2
Standard 2 1.0 ppb PCB	Cal 3
Standard 3 5.0 ppb PCB	Cal 4
Control	Control

   e. Attach the combitip labeled "Conjugate" to the repeater pipettor and set the dial to "1".
   f. Slowly withdraw fluid from the **Enzyme Conjugate** bottle into the combitip until it is full.
   g. Dispense one dose of reagent back into the bottle to fully engage the ratchet mechanism and ensure that the next dose is completely accurate.
   h. Dispense one dose (250 µL) of **Enzyme Conjugate** onto the inside wall of each test tube approximately ¼ inch from the top. *Note that depending on the total number of samples being analyzed, you may need to refill the combitip several times. Make sure you stop dispensing doses and refill while there is still fluid left in the combitip – if you run the combitip completely dry, you may end up dispensing an inaccurate dose into a test tube. Also, keep careful track of the last test tube dosed prior to refilling the combitip so that you do not overdose or skip over a test tube. With the repeater set to "1", you can typically dispense enough doses for 30-40 tubes; ~20 doses set at "2".* For a setting of "4", *it's suggested that you stop and refill after 10 doses, or at the end of each row on the rack.*
   i. Thoroughly mix the bottle of **Magnetic Particles** by slowly swirling (do not shake).
   j. Attach the combitip labeled "Particles" to the repeater and set the dial to "2".

k. Fill the combitip .
l. Dispense one dose back into the bottle to fully engage the ratchet mechanism and ensure that the next dose is completely accurate.
m. Add 500 µL of **Magnetic Particles** down the side of each test tube using the same method described above.
n. Swirl the magnetic particles bottle prior to combitip refills to ensure that particles remaining suspended.
o. Once particles have been added to all test tubes, **Vortex** each test tube for 1-2 seconds at low speed.
p. Once all test tubes have been vortexed, stop and incubate at room temperature for 15 minutes.
q. When the timer stops, combine the upper rack with the magnetic base and press all test tubes completely into the base.
r. Wait two minutes for particles to separate – you will see the particles attached to the side of the test tubes. While waiting, pile approximately 4 paper towels on top of each other and place next to the sink.
s. When the timer stops, carry the combined rack over to the sink being careful that they do not become separated.
t. Using a smooth motion, invert the combined rack assembly over the sink and pour out the tube contents. *Note that the particles will still be attached to the inside walls of the test tubes as long as the top and bottom potions of the rack remain together.*
u. **Keeping the rack inverted**, gently blot the test tube rims on the layers of paper towels. Remove as much liquid as possible but do not bang or shake the rack.
v. Once dried, tilt the rack assembly upright again.
w. Attach the combitip labeled "Wash" to the repeater and set the dial to "4".
x. Fill the combitip from the **Wash Solution** bottle.
y. Dispense one dose of solution back into the bottle to fully engage the ratchet mechanism and ensure that the next dose is completely accurate.
z. Add 1 mL of **Wash Solution** to the inside wall of each test tube using the procedure mentioned above. Refill the combitip with wash solution after every ten doses. Also, add 1 mL of wash solution to the test tube labelled "Blank". The Blank is ready for analysis; no color or stop is added to the Blank, set Blank aside and proceed with other steps for the Cals, Control and Samples.
aa. Once solution has been added to all test tubes, remove each test tube from the rack and **Vortex** for 1-2 seconds.
bb. Combine the upper rack with the magnetic base and press all test tubes completely into the base.
cc. Wait two minutes for particle separation/attachment, then pour out the contents and dry as described previously.

dd. **Repeat the complete Wash step one more time for a total of two wash cycles.**
ee. Once the second wash has been completed and the contents have been poured out, remove the upper rack with the tubes attached from the magnetic base, set magnetic base aside, it is not required for the remaining steps.
ff. Attach the combitip labeled "Color" to the repeater and set the dial to "2".
gg. Fill the combitip from the **Color** reagent bottle.
hh. Dispense one dose of reagent back into the bottle to fully engage the ratchet mechanism and ensure that the next dose is completely accurate.
ii. Add 500 µL of **Color** reagent to the inside of each test tube using the same process mentioned earlier.
jj. Once reagent has been added to all test tubes, remove each test tube from the rack and **Vortex** for 1-2 seconds at low speed.
kk. Once all test tubes have been vortexed, stop and incubate for 20 minutes at room temperature. *Note that during incubation sample fluid will begin to turn blue.*
ll. Attach the combitip labeled "Stop" to the repeater and set the dial to "2".
mm. Fill the combitip from the **Stop Solution** bottle.
nn. Dispense one dose back into the bottle to fully engage the ratchet mechanism and ensure that the next dose is completely accurate.
oo. When the timer stops, add 500 µL of **Stop Solution** to all test tubes using the procedure mentioned previously – sample fluid will turn yellow.
pp. Tubes are ready for analysis as soon as Stop solution has been added – no vortex needed.
qq. Analyze all test tubes within ~15 minutes of Stop solution addition.

9. **Sample Analysis and Results interpretation** (~15 minutes for 50 samples)

Instrument Display	Operator Response
SELECT COMMAND	RUN
RUN PROTOCOL	Scroll down until the cursor is blinking next to "PCB" and press ENTER
SPL REPLICATES (1-5)	Press "1", then press ENTER
BLANK TUBE	
INSERT TUBE	Insert tube labeled "Blank"
EVALUATING TUBE	
REMOVE TUBE (Beep)	Remove tube
CAL#1, REP #1	
INSERT TUBE	Insert tube labeled "Stan 1 Rep 1"
EVALUATING TUBE	
REMOVE TUBE (Beep)	Remove tube
Repeat process until the first 8 tubes have been evaluated (all Cal tubes)	
Store Curve?	Yes
PRINTING DATA	Data will print

PRINTING CURVE	Curve will print
CTRL #1 REP #1	
INSERT TUBE	Insert tube labeled "Control"
EVALUATING TUBE	
REMOVE TUBE (Beep)	Remove tube
STORE CALIBRATION	Press "YES"
SPL #1 REP #1	
INSERT TUBE	Insert first sample tube
EVALUATING TUBE	
REMOVE TUBE	Remove tube
SPL #2 REP #1	Insert second sample

Continue until the 20th sample has been evaluated, then press "STOP".
Tear off the printout from the printer and label with the pans #s analyzed and dilution factor of analyzed tube.

Repeat the entire process rerunning the standards/control every 20 samples until all samples have been evaluated. *Note that evaluation of all samples should be completed within 15 minutes.*

Once all samples have been evaluated, be sure to x-reference the SMPL # from the printout with the Pan # and dilution factor.

Appendix B
Standard Operating Procedures

MONITORING WELL/PIEZOMETER INSTALLATION

1.0 PURPOSE

The purpose of this procedure is to ensure that monitoring wells and piezometers are properly installed after the well boring is drilled.

2.0 SCOPE

This procedure applies to all Jacobs personnel and subcontractors installing monitoring wells and piezometers.

3.0 REFERENCES

1. Aller, L., et al. 1989. *Handbook of Suggested Practices for the Design and Installation of Ground-Water Monitoring Wells.* National Water Well Association, U.S. Environmental Protection Agency (EPA). EPA 600/4-89/034.
2. American Society for Testing and Materials. 1994. *ASTM Standards on Ground Water and Vadose Zone Investigations.* D 5092 - 90. 2nd edition. ASTM, Philadelphia, PA. pp. 278-288.
3. Barcelona, M.J., J.P. Gibb, J.A. Helfrich, and E.E. Garske. 1985. *Practical Guide for Ground-Water Sampling.* EPA/600/2-85/104. pp. 47-72.
4. Massachusetts Department of Environmental Quality Engineering. 1991. "Standard References for Monitoring Wells."
5. Driscoll, F.G. 1986. *Groundwater and Wells.* Johnson Division, St. Paul, MN. pp. 395-463.
6. Nielsen, D.M. 1991. *Practical Handbook of Ground-Water Monitoring.* Lewis Publishers. 717 p.
7. Todd, D.K. 1980. *Ground-Water Hydrology.* 2nd edition. pp. 164-193.
8. EPA. 1991. *Groundwater Volume II: Methodology*, EPA/625/6-90/016b, pp. 1-21.
9. EPA. 1986. *RCRA (Resource Conservation and Recovery Act) Ground-Water Monitoring Technical Enforcement Guidance Document.* OSWER-9950.1. pp. 71-94.

4.0 DEFINITIONS

1. Annular Space or Annulus: the space between the borehole wall and the well casing, or the space between the casing pipe and well casing.
2. Bentonite Seal: a seal with expansion potential placed above the filter pack to ensure that a positive seal is obtained above the filter pack.
3. Filter Pack: a chemically inert, uniform, well-rounded material (sand or gravel) that is placed in the annulus of the well between the well screen and the surrounding formation to prevent formation material from entering the screen.
4. Monitoring Well: a well constructed by various techniques for the purpose of extracting groundwater for physical, chemical, or biological testing, or for measuring water levels.
5. Piezometer: a well installed to measure the hydraulic head.

6. Surge Block: a plunger-like tool consisting of rubber or Teflon discs sandwiched between steel discs that may be solid or valved; used to alternate flow from the well casing into the surrounding formation.
7. Tremie Pipe: a pipe (usually small diameter) that carries materials to the bottom of the borehole and allows for placement of materials upward from the bottom without introducing appreciable air pockets and caved formation materials.
8. Well Casing: an impervious durable tubular product that is a permanent feature of a well and designed to provide access from the ground surface to some point in the subsurface, and to serve as a passage for groundwater level measurements and sample collection devices.
9. Well Screen: a section of casing that has been slotted to allow for free movement of water into the well.
10. Well Sorted: clastic sediment or rock that consists of particles having approximately the same size.
11. Annular Seal: the material placed between the borehole wall and the well casing.
12. Surface Seal: the material placed above the annular seal from two feet below ground surface to ground surface.

5.0 GENERAL

A variety of drilling techniques may be necessary to install monitoring wells, due to anticipated variation in geologic environments across the MMR area. Drilling techniques utilized may include hollow-stem auger, screened hollow-stem auger, air rotary, sonic, or dual rotary. These are described below:

- Hollow-stem auger drilling is commonly used for monitoring well drilling. The drill rig will be mounted on a heavy duty truck or an all-terrain vehicle (ATV).
- Screened hollow-stem auger drilling can provide water samples to produce a vertical contaminant profile.
- Sonic drilling uses single or multiple size temporary steel casing to install single or double well settings.
- Air rotary drilling, which uses air or air mist, is an alternative for drilling deep wells.
- Dual rotary drilling should be used to drill and install deep monitoring wells (where subsurface conditions dictate usage).

Piezometers typically have a 0.75- to 1.0-inch-diameter casing with an attached screen used primarily to monitor the static water level. Natural cave in is allowed to fill the annular space surrounding the piezometer screen and casing.

Ensuring a successful well installation requires that the procedures used for installing each component of the well are followed and well documented. There are six essential components of a well installation:

- well casing and well screen, including top and bottom caps
- filter pack
- bentonite seal
- annular seal
- surface completion and well protection
- field logbooks.

6.0 RESPONSIBILITIES

6.1 Project Manager

Each *Project Manager* shall ensure that the well installation procedures used are in compliance with these procedures and the requirements of the enforcing agencies. Alternate installation requirements and procedures provided by local agencies, and modifications due to unusual conditions must be documented, approved by the affected parties, and be, at a minimum, equal to these procedures in terms of safety.

The *Project Manager* shall develop or direct the preparation of a detailed sampling plan that includes the specifics of the well installation design, particularly the materials and procedures to be used.

6.2 Drilling Manager or Environmental Support Services Manager

The *Drilling Manager* or *Environmental Support Services Manager* shall assure that the well installation procedures used are in compliance with the sampling plan and this TECH-002, and that the *Field Team Members* are trained in the procedures.

6.3 Field Team Leader

The *Field Team Leader* shall know the requirements for well installations, and shall maintain adequate documentation of the installation process and materials used to ensure that proper well installation has been performed and is defensible.

7.0 PROCEDURE

Once the well boring is at the desired depth, the following procedures should be followed to ensure the proper installation and completion of the monitoring well to the desired depth.
Natural collapse and bentonite may be used to backfill the borehole to the required screen interval. Bentonite shall be used in areas where silts and clays were encountered.

7.1 Well Casing and Well Screen

7.1.1 Materials

A variety of construction materials are used for the casings and well screens. The type of material chosen is based on several site-specific factors, including:

- geologic environment (i.e., consolidated or unconsolidated)
- natural geochemical environment (e.g., metals, salt water intrusion)
- anticipated well depth (schedule 40 or schedule 80 PVC)
- types and concentrations of suspected contaminants (e.g., chlorinated solvents will affect PVC over time)
- design life of monitoring well
- well drilling or installation methods
- ease in handling the material

- cost
- availability.

Determining screen length depends on the purpose of the monitoring well and aquifer characteristics. To obtain specific information about water quality and hydraulic characteristics, well screens are usually 5 to 20 feet long. The standard screen slot size is 0.010 inch, unless field conditions indicate otherwise and approval of the technical manager has been obtained. The material used for well screens is generally selected based on the same guidelines used for selecting well casing.

The type of well casing and well screen material to be used, screened interval, specific material decontamination procedures and requirements, and screen slot size will be provided in the project sampling plan. General decontamination procedures are provided in procedure MMR TECH-036. The pre-calculated and actual quantities of materials used in the well installation must be documented in the field logbook. The manufacturer's technical specifications and data sheets for well materials shall be maintained on file. A statement of cleanliness for pre-cleaned material shall be included in this file. These documents will not accompany the well materials delivered to the field site. The well casing shall be sealed in plastic. Condition of well materials shall be documented in the field log.

7.1.2 Installation Procedures

The following procedures shall be followed when installing well casings and well screens:

- All well casing and screen material shall be assembled and installed with sufficient care to prevent damage to the sections and joints.
- Sections of well casing and screen must be connected by a mechanical method, such as flush threading, to prevent introducing contaminants, such as glue or solvents, into the well.
- Prior to installing the section(s) of well screen into the well boring, an end cap must be placed at the bottom of the well screen.
- The casing *must be* suspended to provide 18 to 24 inches of filter pack below the end cap during installation. | Rev. 5
- Prior to the addition of the filter pack, bentonite seal and annular seal, a cap shall be placed on top of the casing to avoid well materials from entering the well casing.
- A completed monitoring well shall be sufficiently straight to allow passage of pumps or sampling devices.

7.2 Filter Pack

7.2.1 Materials

Filter pack materials must be poorly graded (well sorted) to ensure good permeability and hydraulic conductivity of the materials near the screen. The materials used should be chemically inert, well rounded, and slightly coarser than the surrounding formation. Using coarser material increases the effective well diameter.

Filter pack material shall be obtained from known clean sources and should be washed and properly packaged for handling, delivery, and storage. The filter pack shall meet the National

Sanitary Foundation (NSF) standards and be packaged in properly sealed and marked packages. Field notes shall document NSF labeling and any associated lot/identification numbers.

The filter pack is designed based on the anticipated and tested grain size distribution in the screened formation, and in conjunction with the size of well-screen openings. The anticipated size of filter pack materials to be used will be designed prior to well installation and presented in the project sampling plan. The filter pack standard shall be equal to FILTERSIL ™ sand size #00N or #00 unless field conditions indicate otherwise and approval of the technical manager has been obtained. Filter packs shall not be combined.

7.2.2 Installation Procedures

The following procedures shall be followed to optimize the installation of the filter pack and the quality of the well:

- The well boring should allow for placement of the filter pack around the well screen and between 18 and 24 inches of filter pack below the well end cap.
- The volume of the well annulus (i.e., filter pack required) must be pre-calculated and documented in the field logbook; and the volume of the filter pack installed must be monitored and documented to ensure that the filter pack placement is complete.
- When using cased borehole drilling methods, the annulus between the well casing and drill stem may serve as the tremie pipe when using filter pack materials of a uniformity coefficient less than 2.5. Installation of filter pack by slurry through a tremie pipe should be undertaken only when no other practical method exists, and then only using formation water or clean water undergoing quality control laboratory analyses.
- The filter pack must be emplaced and measured in approximately 2-foot lifts to ensure that bridging does not occur.
- The depth to the top of the filter pack must be periodically monitored using a sounder or weighted measuring tape, and noted to ensure uniform placement.
- The filter pack is to be settled using a surge block for approximately 5 to 10 minutes or by sonic vibration prior to final top-off.
- The depth of the top of the filter pack shall be measured to verify the thickness of the pack and to ensure proper placement of a minimum of 30 to 36 inches above the well screen.
- Under no circumstances shall the filter pack extend into any aquifer other than the one to be monitored.
- If the selected filter pack is coarser than #0 Morie Sand, then a minimum 1 foot of fine silica sand ($\geq$ Grade 30) must be placed directly above the filter pack to prevent high pH solutions from the bentonite seal and cement based seals from invading the filter pack during curing.

7.3 Bentonite Seal

7.3.1 Materials

A bentonite seal is used to prevent communication between the filter pack and the natural cave-in material above the screen. The permeability of the seal must be one to two orders of magnitude less than that of the surrounding formation. The seal must be chemically compatible with the anticipated contaminants and chemically inert so that it does not offset the quality of ground-water samples.

Fine-grained forms of bentonite, such as granules and powder, are usually employed for seals placed above the existing water level. A bentonite slurry is normally used for placement of the bentonite seal below the existing water level. Coarse forms of bentonite, such as pellets and chips, can also be used for placement of the bentonite seal below the existing water level when sonic drilling is used, provided the casing is vibrated during retraction.

7.3.2 Installation Procedures

The following procedures shall be followed for placement of the bentonite seal:

- Ten feet of bentonite seal material shall be placed above the filter pack.
- The seal material must be emplaced using a tremie pipe when possible to prevent the possibility of bridging. When using cased borehole drilling methods, the annulus between the monitoring well casing and drill stem may serve as the tremie pipe.
- The depth to the seal shall be measured using a sounder or weighted measuring tape to ensure that the thickness of the seal meets the design requirements.
- The amount of water added to the bentonite used must be as stated in the manufacturer's specifications.
- The quantities of seal material used shall be documented in the field logbook.
- The water added to the bentonite for hydration or to mix slurry shall be from an approved source, of suitable quality, free of pollutants and contaminants; and the volume added must be documented in the field logbook.

7.4 Annular Seal

Natural collapse of the formation will be used as the primary seal for the annulus. If during drilling and sampling it is determined that a silt and/or clay zone is present in the formation then a bentonite seal shall be used to seal that zone. The seal shall be installed to ensure that the zone is properly back filled to prevent the downward migration of contaminants. The bentonite seal can be either chips or slurry and shall be placed as discussed in Section 7.3. In areas where the borehole does not collapse, such as the dry zone above the water table, clean sand may be used for backfill. The clean sand shall be uniformly sized with a grain size less than 1.85 mm. The clean fill material shall meet the National Sanitation Foundation Standards and be packaged in properly sealed and marked packages.

7.5 Surface Completion and Well Protection

Two types of surface completions are typical to monitoring well installations: (1) aboveground completion and (2) flush-mounted completion. An aboveground completion is generally preferred. However, a flush-mounted completion may be specified or required. The purposes of surface completions and well protection are to prevent surface runoff from entering and infiltrating down the well annulus, and to protect the well from accidental damage or vandalism. Upon completion of the well installation, the monitoring well shall be properly surveyed and the measurements documented.

7.5.1 Surface Seals

No matter what the type of surface completion, there must be a surface seal of concrete around the protective well casing filling the upper annular space. A surface seal is a separate seal emplaced above but not connected to the bentonite seal. For surface completions set in cold weather, an accelerator must be added. Rev. 5

7.5.2 Aboveground Completions

The following procedures shall be followed for aboveground completions:

- The well casing shall extend 2 to 3 feet above the ground surface.
- A protective casing will be installed around the well riser pipe. The protective casing shall be positioned and installed in a plumb position. Concrete (surface seal) will then be placed above and around the base of the protective casing up to and becoming part of the surface concrete pad. The seal shall not extend below the base of the protective casing to allow the draining of any trapped water from installation and sampling of the well. Rev 5
- Protective casing will be anchored below the frost depth (2 ft bgs) by the surface seal and extend a minimum of 4 inches above the well casing.
- The protective casing will be painted green or another color chosen by the client.
- A weatherproof locking cap shall be installed on the protective casing, ensuring adequate clearance between the top of the well casing and bottom of the locking cap.
- A concrete surface pad shall be placed surrounding the well protective casing. The pad shall be 3 feet square by 4 inches thick and sloped away from the protective casing.
- Well protection posts shall be placed around wells in any area where there is vehicular traffic. Usually, three or four 3-inch diameter concrete-filled steel posts will be installed. Posts shallshould be placed about two feet below ground surface and shall rise a minimum of four feet above ground. The posts shall not be placed in the concrete pad. Posts will be painted to match protective casing.
- A well identification tag shall be affixed to the protective casing by riveting the ID tag to the steel casing. Internal ID tags shall be banded to each well casing riser pipe within the protective casing.

7.5.3. Flush-Mounted Completions

The following procedures shall be followed for flush-mounted completions:

- Well casing placed must be cut off below grade, leaving enough space for the placement of an end plug or casing cap at each well.

- A protective structure, such as a utility or Christie valve box assembly, will be installed around the well riser pipe and extend below the frost depth (2 ft bgs). The surface seal will be placed above and around the base of the valve box up to and becoming part of the concrete surface pad. The seal shall not extend below the base of the valve box assembly to allow the draining of any trapped water from installation or sampling. The protective structure shall be centered in a 3-foot-square concrete pad sloped away from the structure. For flush-mounted completions located in high traffic areas, completion will follow the procedures outlined above except that a traffic-rated cement or steel vault will be used and cemented flush with the traffic surface. For these flush-mounted completions, care should be used to ensure that the bond between the protective structure and the cement surface seal, and the protective structure and the removable cover are watertight. Use of expanding cement and flexible gaskets are suggested.
- Where significant amounts of runoff occur, additional protection measures may be required.
- A well identification tag shall be affixed to the protective structure by riveting the ID tag to the structure. Internal ID tags shall be banded to each well casing riser pipe within the protective valve box.

8.0 RECORDS

All materials and procedures used during installation of the well shall be documented in field logbooks, as detailed in the technical procedure MMR TECH-035, Field Logbooks.

Reviewed by: ______________________________
Quality Assurance Manager

Approved by: ______________________________
Program Manager, Plume Response Program

WATER LEVEL AND TOTAL DEPTH MEASUREMENTS

1.0 PURPOSE

The purpose of this technical procedure is to describe the equipment and methods used to accurately determine water level and total depth in a groundwater monitoring well, pumping well, or piezometer.

2.0 SCOPE

This procedure applies to all Jacobs personnel and subcontractors who take measurements of water levels and total depths in wells. The procedure is applicable to the sampling of monitoring wells and must be performed prior to any activities, such as purging or aquifer testing, that may disturb the water level.

3.0 REFERENCES

1. Driscoll, F.G. 1986. *Groundwater and Wells.* St. Paul, MN: Johnson Division.
2. Thornhill, Jerry T. 1989. "Accuracy of Depth to Ground Water Measurements," from EPA Superfund Ground Water Issue, EPA/540/4-89/002.
3. U.S. Department of the Interior (USDI). 1981. *Groundwater Manual, A Water Resource Technical Publication.* Water and Power Resources Services. Denver, CO: U.S. Government Printing Office.

4.0 GENERAL

Water level data are used to determine the hydraulic gradient in an aquifer and changes in water levels over time. The water level and total depth are used to calculate the volume of standing water in the well. This volume is used to estimate the amount of water to be purged from a well prior to sampling, and to establish when wells are fully recharged following purging and slug testing.

This technical procedure requires the use of an electronic water level device that employs a battery-powered probe assembly attached to a cable marked in 0.01-foot increments. When the probe makes contact with the water surface, a circuit is closed and energy is transmitted through the cable to sound an audible alarm. This equipment will have a sensitivity adjustment switch that enables the operator to distinguish between actual and false readings caused by the presence of conductive, immiscible components, such as oil or gasoline on top of the groundwater, or wet conditions in a well above the water-table piezometric surface. The manufacturer's operating manual, which may be obtained from the Equipment Manager, should be consulted for instructions on use of the sensitivity adjustment.

The measurements of static water level and total depth must be taken at an established reference point, generally from the top of the casing at the surveyor's mark. The mark should be permanent, such as a notch or mark on the top of the casing. If the surveyor's point is not marked at the time of water level measurement, the north side of the casing should be used and marked. All equipment shall be decontaminated before and after introducing the equipment to the well, following procedures in technical procedure MMR TECH-036.

If it is not possible to measure the depth of a well in which pumping equipment has been installed, the as-built construction plans will provide the total depth.

5.0 RESPONSIBILITIES

5.1 Project Manager

The *Project Manager* shall ensure that the procedures for measuring static water level are in compliance with these procedures and the requirements of the enforcing agencies.

5.2 Sampling Coordinator

The *Sampling Coordinator* shall ensure that the appropriate quality control measures are included and followed as part of water level and total depth monitoring activities.

5.3 Sampling Team Leader

The *Sampling Team Leader* shall ensure that specific procedures for water level, depth measurement and decontamination of the equipment are followed.

5.4 Equipment Personnel

The *Equipment Personnel* shall ensure that water level meter's tape length is calibrated annually.

6.0 PROCEDURE

6.1 Equipment

- Water level indicator with audible alarm and a cable marked in 0.01-foot increments. The point on the probe that triggers the alarm corresponds to the zero point. The water level indicator shall be calibrated according to the manufacturer's instructions. | Rev 4
- Additional weight may be necessary at depths deeper than 80 feet due to the buoyancy of the cable when the weight of the tape is approximately equal to or greater than the weight of the probe.
- Water level indicator operating kit including a 1-liter container of potable water.
- One steel measuring tape shall be used as a reference to accurately calibrate the water level meter's length. | Rev 4

6.2 Static Water Level Measurement

The static water level shall be measured each time a well is sampled. This must be done before any fluids are withdrawn and before any purging or sampling equipment enters a well.

If the well is sealed with an airtight cap, allow time for equilibration of pressures after the cap is removed before taking water level measurements. To verify equilibration, water level readings should be taken approximately three minutes apart to determine whether the water level is static. The water level is considered static if two consecutive readings are within 0.01 feet. The procedure is to record the first static water level measurement and then record the well's total depth before collecting the second water level measurement.

With the water level indicator switched on, slowly lower the probe until it contacts the water surface, as indicated by the audible alarm. Raise the probe out of the water until the alarm turns off. Continue raising and lowering the probe until a precise level is determined.

Record the reading on the cable at the established reference point to the nearest 0.01-foot. Record the other data required in Section 7.0 (Records).

6.3 Total Depth Measurement

Slowly lower the water level indicator, with weight attached if necessary, until the cable goes slack. Raise and lower the probe until the precise location of the bottom is determined.

Record the reading on the cable at the established reference point to the nearest 0.01-foot. The measurement must be adjusted for the offset between the bottom of the probe and the water level sensor. Record data required in Section 7.0 (Records). | Rev 4

The reference point for the total depth measurement is the bottom of the plumb attached to the water level indicator. Since, measured values must be adjusted for the offset between the bottom of the plumb and the water level sensor, this distance on the probe should be measured in the field and added to the measurement.

6.4 Synoptic Water Level Survey

Synoptic water level surveys are performed to determine the hydraulic gradient of the aquifer within a limited period of time (typically one day). These surveys can include as little as two locations and as many as several hundred locations. If a water level survey consists of over 20 locations, then two or more crews may be required to complete the survey with a day's time.

The following procedures and quality checks shall be performed for each synoptic water level survey.

- Sampling Manager receives and reviews a Request for Services for a synoptic water level survey. Access issues and preliminary reconnaissance of the requested water level locations are reviewed prior to field crew mobilization.
- The Sampling Coordinator assigns water level locations and an appropriate amount of duplicate locations as a quality control measure.
- Each field crew will be equipped with a personal water level indicator operating kit. The kit shall include a 1-liter container of potable water. Prior to collecting static water level measurements, the field crew shall test the operation of the their water level indicator by submerging the probe into the 1-liter container of water until the meter's alarm sounds and light illuminates. This quality check shall be performed to ensure that there is accurate probe sensitivity. | Rev 4 | Rev 4
- Prior to field mobilization, all field crews shall measure one predetermined monitoring well as a control for water level meter calibration. Static water level and total depth shall be measured at the common well and the Sampling Coordinator will tabulate the measurements recorded by each field crew to be included in the project file. If each crew's measurements are within an acceptable range of the others, equal to or less than 0.1-ft,

then all field crews will be permitted to complete the scheduled assignments. If one or more water level indicators do not calibrate within the acceptable range, a new water level indicator(s) will be issued and static water level and total depth measurements will be performed at the common well using the replacement indicator(s).

- Upon completion of the synoptic water level event, the duplicate water level measurements shall be tabulated by the Sampling Coordinator and reviewed for accuracy. A spreadsheet listing the duplicate water level measurements shall be included in the project file. If duplicate measurements are found to be greater than 0.1-ft from the survey measurement, then a third field crew will be dispatched to the water level location to confirm either the survey or duplicated measurement. Accurate water level measurements will then be transferred to Data Management for input into the database.

6.5 Water Level Meter's Tape Calibration

The water level meter's tape calibration is performed annually to determine the accuracy of the tapes' measurement. The following procedures and quality checks shall be performed for each water level meter.

- The equipment calibration crew will secure a flat 300' area.
- Reference points will be marked using a measuring wheel and safety cones.
- One 300' steel tape will be used as the standard for calibration. Rev 4
- Each water level meter is then unreeled parallel to the steel tape. The water level meter's sensor is matched against the 0.0 mark of the steel tape by the first crewmember. The second member will match the water level tape's maximum length against the steel tape.
- The unreeled water level meter is placed alongside the 300' tape. This is done to ensure accurate measurements. Rev 4
- One crewmember will then check the tape for kinks, twists, and straightness.
- The meter's length will then be measured against the steel tape for accuracy. One crew member will hold the steel tape and the water level meter taut and the second member will measure the meter against the tape at 50' increments to its total length for accuracy. Rev 4
- Each water level meter shall be labeled as calibrated with the crewmember's initials. If a deficiency has occurred, the label will show the range of accuracy (+/- 0.00-ft). Meters with non-linear or cumulative deficiencies greater than one inch in 300 feet are unacceptable for use. Rev 4
- All water level meter calibrations are recorded in a document-controlled calibration logbook. Rev 4
- The water level meter calibration logbook shall include the following sections: water level meter property number, calibration tape number, tape length differential +/-, meter brand name, total length, property: USAF or JEG, calibration date, initials of crewmember, repairs (if necessary), assignment: department or initials, discontinued, weighted, comments, approx. date or purchase. Rev 4

7.0 RECORDS

Rev 4

The water level meter calibration logbook is a quality record and will be maintained in accordance with technical procedure MMR TECH-035.

All field notes for water level and well depth measurements will be recorded in accordance with technical procedure MMR TECH-035, Field Logbook.

Reviewed by: ____
Quality Assurance Manager

Approved by: ____
Program Manager, Plume Response Program

FIELD MEASUREMENTS USING THE YSI 6820 and 6920 WATER QUALITY METERS

1.0 PURPOSE

The purpose of this Technical Procedure is to describe the step-by-step methods for calibrating, maintaining, and operating the YSI 6820 and 6920 water quality meters.

2.0 SCOPE

This procedure applies to all Jacobs personnel and subcontractors with responsibility for Water Quality Determinations with the YSI 6820 and 6920.

3.0 REFERENCES

1. YSI Inc. 1996. *6820 Multi-Parameter Water Quality Monitor Instruction Manual.* YSI Incorporated, Yellow Springs, Ohio.
2. YSI Inc. 1996. *YSI Model 610-DM Operations Manual.* YSI Incorporated, Yellow Springs, Ohio.
3. *YSI Inc. 1998.Environmental Monitoring Systems Operations Manual. YSI incorporated , Yellow Springs, Ohio.*

4.0 DEFINITIONS

1. Sonde: A device that houses eight field-replaceable sensors designed to measure dissolved oxygen (DO), conductivity, temperature, pH, oxidation reduction potential (ORP) and turbidity.
2. Terminal: The 610-DM Terminal is a display terminal and data logger by which the sonde communicates readings.
3. Flow-through cell: The flow through cell is an attachment for the sonde that allows air-tight water quality measurements of small streams of water (low flow), such as water pumped from a piezometer or monitoring well.

5.0 GENERAL

The YSI 6820 and 6920 water quality meters are multi-parameter, water quality and data collection systems. They are intended for use in research, assessment, and regulatory compliance applications. Instructions for maintenance will be described in the operations manuals (YSI, 1998) provided by the manufacturer. Calibration shall follow protocols designated in the calibration checklist located in each instrument's calibration logbook.

6.0 RESPONSIBILITIES

6.1 Task Manager

The *Task Manager* shall assign trained, qualified personnel to take multi-parameter measurements with the YSI and ensure compliance with this Technical Procedure.

6.2 Field Team Leader

The *Field Team Leader* will oversee the daily operations as related to multi-parameter measurements with the YSI. This individual will supervise the collection and documentation of all field data generated. It is also the responsibility of the *Field Team Leader* to ensure that the equipment used is calibrated before operation and maintained correctly.

7.0 PROCEDURE

7.1 MATERIALS

- YSI 6820 or 6920 Sonde
- YSI 610D Data Logger
- Smart Terminal connector cable
- 610 Data Logger Stand
- sonde guard
- flow-through cell
- discharge hoses (2)
- sonde stand
- Concrete or plywood pad
- Heavy-duty wire ties
- Chain and Lock
- Metal Securing Stake (preinstalled at monitoring location)

7.2 Calibration

The instrument shall be calibrated daily according to the calibration checklist specifically developed for the instrument being calibrated. The checklist is included as Attachment A. Daily calibration procedures will be retained in a bound document with an assigned document number.

7.3 Decontamination

The flow-through cell and discharge hoses will be decontaminated according to the decontamination procedures in TECH-036. To decontaminate the sonde, simply rinse with analyte-free water. The 610-DM terminal shall be wiped clean with a moist paper towel as necessary.

7.4 YSI Field Usage (Discrete Measurements)

7.4.1 The procedures for measuring water quality parameters with the YSI 6820 and flow-through cell (in 610 Logging Mode) are as follows:

- Calibrate instrument in accordance with the instrument-specific calibration logbook.

- Set sonde on sonde stand and secure with adjustable chain.
- Secure discharge hose from Grundfos pump to influent connector (bottom) of flow-through cell. Connect short discharge hose to effluent connector (top) of flow-through cell and run into 55-gallon drum.
- Connect the 610-DM and the sonde with the connection cable by securing the silver end of the cable to the silver fitting at the top of the sonde and by securing the copper fitting on the cable to the copper fitting on the 610-DM.
- When turbidity has moderated, allow flow-through cell to completely fill with water. A continuous effort shall be made to keep air bubbles out of the flow-through cell.
- Once turbidity has moderated, allow flow-through cell to completely fill with water.
- Press the Power key on the 610-DM.
- Arrive at Main Menu by pressing the Esc. key until MAIN appears at the top of the screen.
- Toggle down to 610 Logging Mode and press Enter. LOG will appear at the top of the screen.
- Toggle up to Setup Header and press Enter.
- Toggle to File Name. Using arrows for direction and the number pad (press Shift to enter numbers) enter in up to an ***8 digit*** well code. Press Enter to secure File Name. Data will be logged to this name.
- Toggle to Site ID. In the same manner as above, enter in up to a ***10 digit*** well code that is more specific. The site name will embed in the file. Press Enter to secure Site ID.
- Press the Esc key until LOG appears at the top of the screen.
- Toggle down to Start 610 Logging. Press Enter. New File? will appear, press Y. Press Enter. Weather? will appear. Press N. This begins the logging session as specified in the Set Up Header Menu.
- A countdown will begin in the top right-hand corner of the screen. The YSI 610-DM will display a reading for parameters averaged every 5 minutes.
- Record parameters into logbook at 5-minute intervals.
- When parameters have stabilized, press Power key to terminate Logging Mode on the 610-DM before sampling.

7.4.2 The procedures for measuring water quality parameters with the YSI 6820 without a flow-through cell (in Run Mode) are as follows:

- Connect the 610-DM and the sonde with the connection cable as described above.
- Remove sonde protective cover, install protective sleeve with openings and lower into sample media.
- Press Power key to power on 610-DM.
- Press Esc until MAIN or RUN appears on the screen. When in Main Menu, select Run Mode and press Enter.
- Water Quality Parameters will appear on the 610 screen. There will be no countdown as with the 610 Logging Mode because numbers are not

averaged every 5 minutes. Real time numbers will appear on the 610 screen and change accordingly.

- Record parameters into logbook..

Press Power when parameters are completed (Surface Water Sampling SOP Tech-017) to end session.

NOTE: The run mode and 610 Logging Mode can be used interchangeably either with or without a flow-through cell. In the 610 Logging Mode, the turbidity wiper will run automatically at 5 minute intervals. In the 610 Run Mode, the wiper will not engage automatically. The "T" button on the key pad must be pressed down to engage the wiper.

7.5 Continuous Logging YSI

7.5.1 Uploading to the 610 from the YSI 6920 sonde

- Arrive at site. Make field notes of the condition the YSI 6920 is in (i.e. weeds, direction probes facing, any movement or change to surroundings that may have occurred, etc.).
- Gently pull YSI 6920 sonde from the water.
- Attach the 610-DM data logger to the YSI 6920 sonde using the Smart Terminal connector cable.
- Press the **Power** key on the 610-DM data logger.
- Select Deploy Sonde and press **Enter**. "MAIN" will appear on the top of the screen.
- Select RUN and press **Enter**. "RUN SETUP" will appear at the top of the screen.
- Select Unattended Sample and press **Enter**. "LOGGING" will appear at the top of the screen.
- Select Stop Logging and press **Enter**. "LOGGING" will appear at the top of the screen.
- Select Yes and press **Enter**. You will be sent back to previous screen, but now it will read "UNATTENDED SETUP" at top of screen.
- Press **Esc** until "MAIN" appears at the top of screen or until you are unable not to **Esc** any further.
- Select Communications and press **Enter**. "COMM" will appear at the top of the screen.
- Select Kermit 610←SONDE and press **Enter**. "FILE" will appear at the top of the screen.
- Select Upload and press **Enter**. "FILE SAMPLES" will appear at the top of the screen.
- Select the "file name" and press **Enter**. "TIME WINDOW" will appear at the top of the screen.
- Select Proceed and press **Enter**. "FILE TYPE" will appear at the top of the screen.
- Select PC6000and press **Enter**. "UPLOAD" will appear at the top of the screen and the 610 will begin uploading the file. Once all the data is

received the screen will show: "Status: SUCCESSFUL". If uploading is not successful repeat uploading procedure.

7.5.1.1 Field Check of YSI 6920

- As a field check bring a YSI 6820 into the field and take a discrete reading (see section 7.4.2 of this procedure).
- Take these readings at the same location where the YSI 6920 was logging parameters.
- Log these readings into field logbook.
- Disconnect the 610 DM and connector cable from the YSI 6820.
- Connect the 610 DM to the YSI 6920 with the connection cable.
- Place the YSI 6920 into the river (try to situate it as close to the location where the previous readings had been taken).
- Press Power key to power on 610-DM.
- Press Esc until MAIN or RUN appears on the screen. When in Main Menu, select Run Mode and press Enter.
- Water Quality Parameters will appear on the 610 screen. There will be no countdown as with the 610 Logging Mode because numbers are not averaged every 5 minutes. Real time numbers will appear on the 610 screen and change accordingly.
- Record parameters into logbook (make sure to properly decipher which YSI the readings where taken with).

7.5.2 Uploading to the Computer

- Connect the null modem cable (part #4015058533) to the appropriate PC comm port. For most computers this will be comm port 1, but may differ with other machines.
- Open the Ecowatch for Windows program on the PC.
- Using the mouse click on Comm on the toolbar, at the top of the screen. Scroll down to Sonde. The Select COM Port box and select appropriate port and using mouse click on OK. Sonde-"Port" box will open.
- Press the **Power** key on the 610-DM data logger.
- Select Communications and press **Enter**. "COMM" will appear at the top of the screen.
- Select Kermit 610→PC and press **Enter**. "Send All Files" will appear on the top of the screen.
- Select the "File Name" and press **Enter**. The PC will begin receiving the data.
- On the PC, using the mouse select File on the toolbar at the top of the screen. Scroll down to Open. File Open box will appear. Select "File Name" and using the mouse click OK.
- Disconnect the null modem cable (part #4015058533) from the appropriate PC comm port and plug the 610DM Data Logger into the charger where it remains while not in use.

7.5.3 Redeployment and logging setup of the YSI 6920

The procedures for redeployment and logging setup of the Continuous YSI logging (6920) into the field are as follows:

- If applicable, remove sonde protective cover and install the protective sleeve with openings.
- Using the Heavy-duty wire ties, attach the YSI 6920 to the concrete or plywood pad. Strap one wire tie over the top of the 6920 (end closest to the cable hook-up connection) and around the concrete or plywood pad. Strap an additional wire tie through the openings of the protective sleeve and around the concrete or plywood pad (be careful not to place the wire tie near any probes within the protective sleeve).
- Begin Logging:
    - Attach the 610-DM data logger to the YSI 6920 sonde using the Smart Terminal connector cable.
    - Press the **Power** key on the 610-DM data logger.
    - Press **Esc** to get to main screen. "Main " will appear at the top of the screen.
    - Select Deploy Sonde and press **Enter**. "MAIN" will appear on the top of the screen.
    - Select RUN and press **Enter**. "RUN SETUP" will appear at the top of the screen.
    - Select Unattended Sample and press **Enter**. "LOGGING" or "UNATTENDEDSETUP" will appear at the top of the screen.
        - If "LOGGING" appears then that unit is currently logging data and you will need to stop the logging before proceeding. To disengage logging select Stop logging and press **Enter**, "LOGGING" will appear at the top of the screen. Select Yes and press **Enter**. You will be sent back to previous screen, but now it will read "UNATTENDED SETUP" at top of screen.
        - If "UNATTENDEDSETUP" appears at the top of the screen then go to the next step.
    - Scroll down to the File: slot and type in an eight digit file name and press **Enter**.
    - Double-check all parameters: Intrvl(interval), StrtDT:(start date), StarTM:(start time), DurationDas: (duration), etc..
    - Select Start Logging and press **Enter**. "START LOGGING" will appear at the top of the screen.
    - Select Yes and press **Enter**. "LOGGING" will appear at the top of the screen. Once again, it is a good idea to double-check all parameters (i.e Intrvl). If any of the fields need changing then you will need to disengage the logging to make the corrections.
- Disconnect the 610-DM data logger and the smart terminal connector cable from the YSI 6920 sonde and place the protective cap on the threaded cable connection.
- In field: Arrive at the location.

- Connect the YSI 6920 to the metal securing stake using a chain and lock. Connect the chain to the metal ring which is located at the top of the YSI (end closest to cable connector).
- Gently place the YSI 6920 into the river, making sure to place the YSI 6920 (which is on the concrete or plywood pad) with the probes facing into the river current.
- Accurately describe placement procedures in field logbook.

7.6 Storage

The following tasks must be performed at the end of each day's operation of the YSI 6820:

1. Decontaminate instrument according to Section 7.3.
2. Upload data following section 7.5 guidelines.
3. Postcheck pH, conductivity, DO, and turbidity according to Attachment A.
4. Attach each terminal and sonde to its corresponding charger.

7.7 Maintenance

Maintenance will be performed as per the manufacturer's instructions.

8.0 RECORDS

All YSI parameter data collected in the field shall be entered into a bound logbook following the format and guidelines in technical procedure TECH-035, Field Logbook. Copies of the uploaded YSI data reports and plots shall be made and filed accordingly.

9.0 ATTACHMENTS

Attachment I - YSI 6820, 6920 and 610 DM Calibration Checklist

Reviewed by: ____
Quality Assurance Manager

Approved by: ____
Program Manager

(intentionally blank)

Attachment I

YSI 6820, 6920 and 610 DM Calibration Checklist

Government Instrument ID# ____________________	Date: ____________	
DO Calibration	**Calibration**	**Post-Check**
1. Remove the travel cup from the sonde and inspect each individual probe for deterioration and repair or replace as necessary (to include DO membranes). NOTE: Verify DO membrane has no water droplets on it.		
2. Place approximately 1/8 inch of water in the bottom of the Transport Cup. Place the probe end of the sonde into the cup. Make certain the DO and the temperature probes are not immersed in the water. Wait approximately 10 minutes for the air in the transport cup to become water saturated and for the temperature of the oxygen probe to reach equilibrium.		
NOTE: Make certain that the Transport Cup is vented to the atmosphere by loosening the connection until only 1 or 2 threads are engaged.		
3. Connect the sonde (6820) to the 610 DM, if not already connected. Press the "Power" key. Press the "Esc" key and the Main Menu will be displayed. Use the arrow keys to toggle down to the "Calibration Mode" and press ENTER. The display will read "Calibrate Conductivity, dissolved oxy, ISE1 pH, ISE2 ORP, Turbidity." Use the arrow keys to toggle to "dissolved oxy" and press ENTER. Use the arrow keys to toggle to DO% and press ENTER.		
4. Obtain and record the current barometric pressure _______ inches Hg. Multiply inches Hg x 25.4 to obtain millimeters (mm) Hg required for YSI input. At the sonde prompt, enter the barometric pressure (recorded above) and press ENTER.		
5. The DO Calibration screen will appear. Once the DO reading stabilizes, press ENTER to calibrate, record the measurement results here: _______. "Calibration Successful" will appear. Press any key to continue. Press the ESC key twice.		
pH Calibration		
1. Using the arrow keys, toggle down to ISE1 pH and press ENTER. The "pH Calibration" screen will appear. Use the arrow keys to toggle down to "3 point" and press ENTER.		
2. Remove the Transport Cup from the sonde and rinse with de-ionized water. Place the probes into the pH 4 buffer solution. The 610 DM display will ask to enter the 1st pH standard. Press 4 and ENTER.		
3. View the 610 DM display and when the pH reading stabilizes, record the measurement results here: ______ press ENTER to calibrate. Press any key to continue.		
4. Rinse the sonde probes with de-ionized water upon removal from the pH buffer solution.		
5. Press ESC twice to return to the pH calibration screen. Enter 2nd pH will appear. Set the sonde probes into the pH 7 buffer solution and press ENTER. View the 601 DM display and when the pH reading stabilizes, record the measurement results here: ______ press ENTER to calibrate. Press any key to continue.		
6. Rinse the sonde probes with de-ionized water upon removal from the pH buffer solution.		

YSI 6820, 6920 and 610 DM Calibration Checklist

7.	Press ESC twice to return to the pH calibration screen. Enter 3rd pH will appear. Set the sonde probes into the pH 10 buffer solution and press ENTER. View the 610 DM display and when the pH reading stabilizes, record the measurement results here: ______ press ENTER to calibrate. Press any key to continue.		
8.	Rinse the sonde probes with OFW upon removal from the pH buffer solution. Press ESC twice to return to the Calibration Menu.		
	Conductivity Calibration		
1.	Place the sonde probes into the Conductivity solution.		
2.	Use the arrow keys to toggle down to Conductivity and press ENTER. Use the arrow keys to toggle down to "SpCond" and press ENTER. "Cond Cal" will appear on the screen and the display will ask to enter the value of the conductivity standard. Press 1 and ENTER.		
3.	View the display screen and observe the conductivity reading. When the reading has stabilized, record the measurement results here: _____ press ENTER to calibrate. Remove the sonde probes from the turbidity standard and rinse the probes with de-ionized water. Press ESC twice to return to the "Calibration Menu."		
	Turbidity Calibration		
1.	Use the arrow keys to toggle down to "Turbidity" and press ENTER.		
2.	Attach the probe guard. Place the sonde probes into the turbidity standard (0 NTU).		
3.	"TurbidityCalbrt" will appear on the screen. Use the arrow keys to toggle down to "2 point" and press ENTER. The display will ask to enter the value of the first point NTU standard. Press 0.0 and ENTER.		
4.	Press "T" to activate the wiper. View the display screen and observe the Turbidity reading. When the reading has stabilized, record the measurement results here: ____ Press ENTER to calibrate. Remove the sonde probes from the turbidity standard and rinse with de-ionized water. Press ESC twice.		
5.	Place the sonde probes in 100 NTU standard. The display will ask to enter the value of the second point NTU standard. Press 100 and ENTER.		
6.	Press "T" to activate the wiper. View the display screen and observe the Turbidity reading. When the reading has stabilized, record the measurement results here: _____ Press ENTER to calibrate. Remove the sonde probes from the turbidity standard and rinse with de-ionized water. Press ESC once.		
	ORP Calibration		
1.	Use the arrow keys to toggle down to "ISE2 ORP" and press ENTER.		
2.	The display will ask for the value of the ORP standard. Enter the number 231.0 and press ENTER.		
3.	View the display screen and observe the ORP reading. When the reading has stabilized, record the measurement results here: _____ press ENTER to calibrate. Remove the sonde probes from the standard and rinse with de-ionized water. Press ESC three times to return to "Main Menu." The YSI is now calibrated. Press the POWER key to shut-off the 610 DM. Place the YSI 6820 and the 610 DM into its carrying case for transport.		

YSI 6820, 6920 and 610 DM Calibration Checklist

Signature of Calibrator: ______________________________

Decon Status: ______________________________

Initials of Post-checker: ______________________________

	Lot #	Mfg.	Exp. Date
pH 4			
pH 7			
pH 10			
conductivity			
turbidity 100 NTU			
ORP			

Note: Post-checks are done in the same lot numbered solutions unless otherwise documented.

Corrective action taken (if necessary): ______________________________

BORING LOG DEVELOPMENT

1.0 PURPOSE

The purpose of this technical procedure is to present a set of descriptive protocols and standardized reporting formats for use by all field personnel in completing boring logs, sediment core logs, and to standardize lithologic descriptions.

2.0 SCOPE

This procedure applies to all Jacobs' personnel and subcontractor team personnel overseeing the advancement of monitoring well borings, extraction well borings, reinjection well borings, soil borings, sediment core borings, or water sample borings, and recording lithological logs describing those borings.

3.0 REFERENCES

1. American Geological Society, *American Geological Society Data Sheets for Geology in the Field,* Laboratory, and Office, 3rd ed., 1989.
2. Compton, R.R. *Manual of Field Geology*, John Wiley & Sons Inc., New York, NY, 1962.
3. Folk, R.L., Petrology of *Sedimentary Rocks*, Hemphills, p. 170, Austin, TX, 1968.
4. Munsell Color Chart, Soil Test Inc., Evanston, IL, 1975.
5. Terry, R.D., and Chillingar, G.V., *Journal of Sedimentary Petrography*, v. 25, p. 228-234, 1955.
6. American Society for Testing and Materials, D2488-93, Standard Practices for Description and Identification of Soils (Visual - Manual Procedure) Vol. 04.08 p. 337-346, 2000.
7. American Geological Society, Dictionary of Geologic Terms, Anchor Press, Garden City, NY, 1960.
8. American Society for Testing and Materials, D2487-98, Standard Test Method for Classification of Soils for Engineering Purposes.
9. Powers, M.C., A New Roundness Scale for Sedimentary Particles, Journal of Sedimentary Petrology, v. 23, p. 117-119, 1953.

4.0 DEFINITIONS

1. Angularity: pertaining to the sharpness of edges and corners of individual grains. A grain is angular if most of the edges or corners are sharp, and rounded if most are smooth.
2. Cohesiveness: measure of the strength, when air-dried, of an unconfined soil or sediment, or a measure of the cohesion of a soil or sediment when submerged.
3. Lamination: the state of being laminated, specifically the thinnest recognizable layer in a sediment differing from other layers in color, composition, or particle size.

4. Control Number (CCN): number assigned by Site Environmental Evaluation (SEE) to a container or group of containers shipped to a given lab for a given set of analyses. Usually one container gets one CCN, although groups of containers (such as three 40-mL VOA bottles) will often get one CCN because they are seen as a unit.
5. Lithologic: pertaining to the physical characteristics of a rock or sediment.
6. Plasticity: measure of the tendency of a soil or sediment to be deformed without rupturing.
7. Relative Density: the ratio of (1) the difference between the void ratio of a cohesionless soil in the loosest state and any given void ratio, to (2) the difference between the void ratios in the loosest and in the densest states.
8. Sample ID: the unique identifier that Jacobs assigns to a specific environmental sample.
9. Sorting: a measure of the uniformity of particle size(s) in a particular soil or sediment.
10. Texture: the general appearance or character of rock or sediment, including the geometric aspects of, and mutual relations among, its component particles, e.g., the size, shape, and arrangement of the constituents of sediment.

5.0 GENERAL

The log forms attached to this procedure are intended for use in the field during the drilling/coring, sampling, and logging process for soil borings, water sampling borings, and well construction. The purpose of the log form is to clearly document the events and findings of the drilling activity. Most of the information required can be legibly recorded in the field; however, some items, such as the graphic log column, may be reserved for completion in the field office. Completed original log forms shall be retained in a permanent file at the field office. An electronic copy of completed logs will be maintained in the Site Environmental Evaluation (SEE) database.

6.0 RESPONSIBILITIES

6.1 DRILLING MANAGER

The *Drilling Manager* (DM) is responsible for the coordination and scheduling of daily field activities.

6.2 DRILLING SUPERINTENDENT

The *Drilling Superintendent* (DS) is responsible for assuring all paperwork and forms developed during lithologic logging are in compliance with this procedure and are executed throughout the whole data process.

6.3 FIELD GEOLOGIST

The *Field Geologist* performing lithologic logging is responsible for completing consistent, accurate, and uniform lithologic descriptions. The Field Geologist will ensure that all entries have been appropriately reviewed and that any corrections have been made properly. The Field Geologist also must ensure that field activities are properly documented per requirements of this procedure, other applicable procedures, the Field Sampling Plan (FSP), and the *Quality Assurance Project Plan* (QAPP).

6.4 GEOLOGGER

The *Geologger* is the geologist transcribing the handwritten logs into electronic copies. The Geologger is responsible for ensuring that the transcribing is accurate and complete for all logs.

6.5 BORING LOG APPROVER

The final boring log shall be approved by a Certified Groundwater Professional, Professional Geologist, or Professional Engineer. The Project Manager may also designate an alternative person as final reviewer. Section 6.5 does not apply to sediment core collection.

7.0 PROCEDURES

7.1 PROCEDURE FOR LITHOLOGICAL BORING LOGS (SEE SECTION 7.3 FOR SEDIMENT CORE LOG PROCEDURE)

The Lithological Boring Log form (Attachment 1) consists of a title block and nine columns. The title block information is on the first page of each log and an abbreviated version is on subsequent pages. The nine columns contain specific information about the boring. The circled letters correspond to the column discussion in the procedure.

7.1.1 Title Block

The title block must be completed with all available information. If the item requested is not applicable, then N/A shall be recorded in that box.

The title block portion of the form contains general information with regard to project name and number, Location ID of drilling location, investigation area, drilling methods, total depth and diameter of borehole, start and completion dates, depth to static water, depth to first water encountered, and personnel. All requested information shall be provided in this section.

7.1.2 Depth Column

The depth column refers to the depth below the ground surface (column "B" in Attachment 1). All depths shall be recorded in feet. The scale of the log is determined by the depth column. The scale may be adjusted as needed by the Field Geologist for the best and most accurate representation of the data. Most logs show 5-foot intervals. Depth intervals shall be recorded at a consistent depth (e.g., 10, 15, 20, 25...or 10, 20, 30, 40...).

7.1.3 Blow Counts/Core Run Column

The blow counts column or core run column is used to record the number of blows it takes to drive the split spoon sampler 6 inches, or to exhibit the complete interval where a continuous core tool was advanced.

Blow counts provide a qualitative estimate of the relative density for a particular sample interval. Each individual blow count refers to the number of hammer blows required to advance the split spoon 6 inches. Standard penetration test results are based on the use of a 140-pound hammer dropped a distance of 30 inches.

Blow counts shall be recorded as a number for each 6-inch interval of the sampler and shall be recorded in groups of four (e.g., 6/10/10/16).

Continuous core runs shall be indicated by a large "X" placed in the column covering the complete interval attempted (column "C" in Attachment 1).

7.1.4 Recovery Column

The recovery column (column "D" in Attachment 1) shows the amount of sample recovered per sample attempt. Split spoon sample recovery shall be recorded as the portion of sample recovered (in inches) out of the total 2-foot attempt.

When using a continuous core tool, indicate in the recovery column the total amount of core recovered. A large X shall be placed in the column to correspond to the actual recovered interval.

7.1.5 Sample ID/Control Number Column

This column is used for the recording of a Sample ID or Control Number for all samples collected during the advancement of the borehole. If both the sample ID number and the control number are known, both shall be recorded in the column. If only one of the numbers is known, then it shall be recorded in this column. If the known number is a sample ID, then the "control number" heading shall be crossed out. If only a control number is known, then the "Sample ID" heading shall be crossed out. The Sample ID/Control Number Column is indicated as Column "E" in Attachment 1.

7.1.6 PID/FID Column

Field screening results for volatile organics shall be recorded in column "F" in Attachment 1. Readings shall be recorded in parts per million (ppm) for volatile organics and placed at the appropriate depth interval from where the lithology that was screened originated in the borehole.

7.1.7 Unified Soil Classification System (USCS) Column

In this column, the standard USCS classification code is entered adjacent to the corresponding lithology. An entry shall be made at each lithological change or at the top of a new page if the same lithology is encountered. The logging geologist shall determine and record the correct USCS classification from the "Key to Logs" (Attachment 2) standard and put the code in this column (Column "G," Attachment 1).

7.1.8 Graphical Lithology Column

The lithology column ("H" in Attachment 1) presents a graphical representation of the lithology encountered. The graphic used shall correspond to the USCS classification and be from "Key to Logs" (Attachment 2). This graphic will also be exhibited in three-dimensional graphics extracted directly from the logs.

7.1.9 Lithological Descriptions

This section discusses the protocol for recording basic lithologic data (column "I" in Attachment 1) including, but not limited to, lithologic names, texture, composition, color, bedding, and lateral and vertical contacts. In describing lithologies, it is helpful to have a set of references covering items such as the grain size (Attachment 2), degree of sorting (Attachment 4), estimated percent composition (Attachment 5), particle shape (Attachment 6), and lithologic symbols (Attachment 7).

A list of equipment that will be useful in completing lithologic descriptions is provided as "Required Equipment" below:

- field logbook and lithologic log forms;
- project-specific documents;
- clip board;
- plastic sheeting,
- indelible black ink pens or markers;
- 10x magnifying hand lens;
- reference field charts;
- personal protective clothing and equipment;
- health and safety monitoring equipment;
- folding table and chairs;
- camera, film, and scale;
- sample jars (if required);,
- grain size chart, and
- Munsell color chart.

The following descriptive protocol shall be used to classify and document the lithologic description of all lithology recorded. The information gathered will be recorded in the "Description of Materials" column (labeled "I" in Attachment 1) on a lithologic boring log form and in the appropriate field logbook.

7.1.9.1 Predominant Lithology

Determine the predominant lithology or lithologies within the sample interval using the grain-size classification guide provided to you for use in the field or use Attachment 2 in this procedure. If the SAND & GRAVEL portion comprises more than 50 percent, the sediment is named either SAND or GRAVEL, depending on which portion is greater. Similarly, if SAND & GRAVEL comprises 50 percent or less, the sediment is named either CLAY or SILT, whichever comprises the greatest percentage of the sample. This will be the primary description used to identify the soil. The primary lithology will be CAPITALIZED in the description, and be the first entry.

NOTE: Samples from split spoons and small-diameter core tools are not always representative of coarse-grained strata. Be sure to check driller's logs and soil cuttings for boulders, cobbles, gravels, etc., which were encountered during advancement of the boring, and note their presence in the remarks section (column "J", Attachment 1) of the lithologic log.

Because of the fine size of clay and silt, physical properties other than grain size must be used as criteria for identification in the field. The dilatancy or "shaking test" may be used to distinguish between the fractions of clay and silt. In this test, a small amount of sediment is mixed with water to a very soft consistency in the palm of the hand. The back of the hand is then lightly tapped. If the sediment is silty, water rises quickly to the surface of the mixture and gives it a glistening or shiny appearance. Because of the difficulty in distinguishing between silt and clay, it is not necessary to provide the relative percentage of each.

The property of plasticity is characteristic of clays and may be determined using a simple field test. If a sample of moist sediment can be rolled into a long thin thread in the palm of the hand, it contains a significant amount of clay. Silt can seldom be rolled into a thread without severe cracking.

7.1.9.2 Secondary Constituents

Estimate the percentages of secondary and tertiary constituents using Attachments 2 and 5. For mixed-grain sizes, estimate the relative percentages of the sediment sizes within the sample. Table 1 provides a set of descriptive adjectives that shall be used to identify secondary lithologies based on the estimated percent composition.

Table 1 Descriptive Adjectives for Secondary Lithologies

DESCRIPTION	Percent Composition
Trace (tr)	<5%
Trace-little (tr to ltl)	5-11%
Little (ltl)	12-24%
Some (sm)	25-34%
"Y" ending	35-44% (e.g., silty sand)
"And"	45-50% (e.g., silt and sand)

For example, a sample predominantly sand with 40 percent silt would be recorded: silty sand 10 YR 6/4 light yellowish brown. A sand with 15 percent silt would be: sand with little silt, 10 YR 6/4 light yellowish brown.

7.1.9.3 Secondary Modifiers

Identify applicable secondary modifiers (e.g., grain size, sorting, structural/textural features, bedding laminations) and use abbreviated qualifying adjectives as needed. A list of abbreviated qualifying adjectives is presented as Attachments 2 and 3.

7.1.9.4 Relative Density

Relative density can be based on blow counts or drill rates and is used as a prefix in primary lithologic descriptions (Table 2).

Table 2 Relative Densities Based on Blow Counts

Cohesive Soils (Silts & Clays)		Noncohesive Soils (Sands & Gravels)	
No. of Blows	**Relative Density**	**No. of Blows**	**Relative Density**
0-4	Soft (sft)	0-4	Very Loose (v.lsc)
5-8	Firm (frm)	5-10	Loose (lsc)
9-15	Stiff (stiff)	11-30	Medium Dense (m.dnse)
16-30	Very Stiff (v.stiff)	31-50	Dense (dnse)
31-50	Hard (hrd)	Over 50	Very Dense (v.dnse)
Over 50	Very Hard (v.hard)		

7.1.9.5 Color

Color descriptions shall be made using Munsell soil color charts. The description shall include the color designation first, followed by the verbal description (e.g., 10 YR. 5/6 yellowish brown). While color is not an important physical property in itself, it is often an indicator of more important properties. For example, dark green and brown are often an indication of organic matter. When the color of the sediment is uniform, record this with the singular term from the Munsell color chart. If two major and distinct colors are mottled through the sediments, the color description will be modified by the term mottled with the two Munsell color descriptions, e.g., brown and bluish gray, with the color designation following both verbal descriptions, e.g., mottled brown (10 YR 4/3) and yellowish brown (10 YR 5/6).

7.1.9.6 Particle Shape

Particle shape descriptions (for coarse sand and larger, such as gravel) shall be made based on the figure included in this procedure as Attachment 6, which was taken from *Compton's Manual of Field Geology*.

7.1.9.7 Relevant Observations

Record any other relevant observations, such as moisture content, signs of contamination, cementation of particles, mineralogy, bedding, contacts between strata, and unconformities. These may be noted in the description or within the remarks column of the lithologic log.

7.1.10 Presentation Order

Once the information described in Section 7.0 has been gathered for the sample, the sample description shall be recorded on the lithologic log and in the field logbook. In order to maintain consistency, the lithologic description will be presented in the following order:

- MAJOR LITHOLOGY, Secondary Components, Color, grain size, sorting, grain shape, other lithologic components, sedimentary structures/bedding, consistency or relative density, moisture, and other descriptive modifiers as necessary.

EXAMPLE: A sample is visually examined in the field and is found to be comprised of approximately 55 percent medium-grained sand and 40 percent silt. The structure of the sample is massive and the color is yellowish brown. The sample is damp to moist, and the standard penetration test produced a penetration resistance (N) of 16. The description would be as follows: SILTY SAND 10 YR 5/6 Yellowish Brown, medium-grained, trace clay, firm, moist to damp.

7.1.11 Remarks Column

The remarks column is available for comments and observations. Sample collection times, water levels, mud loss, fuel odor, drilling conditions (e.g., chatter), and any other relevant observations may be recorded in this column (Column "J" Attachment 1).

7.1.12 Miscellaneous Notes

Water levels collected during and after drilling shall be illustrated by open and closed triangles. It is often useful to include the time (in military units) that the water levels are measured.

All columns in the lithologic log shall be either filled out with the required information or marked with an "NA" to indicate that the information is not applicable for this location.

7.2 PROCEDURE FOR SEDIMENT CORE LOG

The Sediment Core Log form (Attachment 8) consists of a title block for recording field measurements and specific activity information and eight columns for detailing a sediment core description. Each of the eight columns provides a record of specific properties of a core at a particular horizon.

7.2.1 Title Block

The title block must be completed with all available information. If the item requested is not applicable, then N/A shall be recorded in that box.

The title block portion of the form contains specific information such as Core Location ID, Geologist/Scientist's name, core collection method, and collection date and time.

The title block contains five field measurements to be recorded during sample collection. The five measurements correspond to a letter code A-E, these letter codes play a role in future calculations. The first measurement "A" is the water depth in feet, this is typically performed with a rod and plate type of device although any device able to measure water depth accurately within 0.1 foot is acceptable. "B" the water surface elevation is measured with either a local tide board or survey grade GPS, this measurement is relative to NGVD 29. Either method is acceptable provided accuracy to 0.1 foot is demonstrated. "C," length of corning assembly is the length of the entire assembled coring device including core collection tube. "D," water surface to top of coring assembly is the measurement at the completion of tool advancement from the water surface to top of assembly. "D" is measured to 0.1 foot resolution. "E," length of sediment core is the measurement to the nearest 0.1 foot of the length of sediment core recovery.

The title block section of Attachment 8 contains three calculations utilizing the five measurements listed above. The calculations, similar to the measurements are keyed with letter codes.

- "F" is the elevation of the bottom of the sediment core; this is calculated as: Water Surface Elevation - (Length of Coring Assembly - Water Surface to Top of Coring Assembly) or B-(C-D).
- "G" is the elevation of sediment water interface; this is: Elevation of Bottom of Core + Length of Core, or F+E.
- "H" is an alternate method of calculating the elevation of sediment water interface, this second method may be employed as a quality control measurement. Typically a valid sediment core would have an agreement of less than 1 foot between the two measurements. "H" is calculated as: Water Surface Elevation - Water Depth or B-A.

7.2.2 Elevation Column

The first entry in the elevation column is the elevation of the sediment water interface; this is the top of the core. While describing the core measurements are made from the top in tenths of a foot. To denote changes in lithology, material type, color, consistency, odor, or other pertinent observations an elevation is calculated and recorded along with the appropriate observation. At a minimum the core top and bottom elevation is denoted.

7.2.3 Core Diagram

The core diagram is a field drawing of core attributes and changes in those attributes through its length. The diagram is useful for illustrating different strata within a core. Attachment 7 provides standard graphic patterns utilized to denote specific lithologies.

7.2.4 Lithology – USCS Code

In this column, the appropriate standard USCS classification code is entered adjacent to it's illustration in the core diagram. Attachment 2 provides a guide to the USCS soil codes.

7.2.5 Type

Type is the predominant lithology for a particular horizon, i.e., Clay.

7.2.6 Color

Color descriptions shall be made using Munsell soil color charts. The color designation shall be listed first followed by the verbal description i.e., 10 YR. 5/6 yellowish brown.

7.2.7 Consistency

This is a general description of the soil consistency at a particular horizon, i.e., firm.

7.2.8 Odor

This optional column is used to note observed odors if present, i.e., "rotten eggs."

7.2.9 Comments

This column is reserved for any observations the geologist/scientist may believe is pertinent yet does not fit into any of the other columns.

7.3 POST PERFORMANCE WORK ACTIVITIES

To guard against loss of data due to damage or misplacement of forms, copies of completed pages will be made daily and securely stored at the field office. Upon completion of a field data form, it shall be copied and submitted within one week to the field office file. This includes all automatic data recording media (print-outs, logs, disks, or tapes) and activity-specific data collection forms.

The field geologist will ensure that all entries have been appropriately reviewed and that any corrections have been made properly.

8.0 RECORDS

Log forms shall be filled out in accordance with the technical procedure. A field copy shall be retained in the project specific files at the Site office. A copy shall also be provided to Data Management for processing.

9.0 ATTACHMENTS

Attachment 1	Boring Log
Attachment 2	Key to Logs (Unified Soil Classification System)
Attachment 3	Standard Abbreviations for Lithologic Descriptions
Attachment 4	Description of Sorting for Unconsolidated Sedimentary Materials
Attachment 5	Comparison Chart for Estimating Percentage Composition
Attachment 6	Particle-Shape Reference Guide
Attachment 7	Lithologic Symbols
Attachment 8	Sediment Core Log

Reviewed by:____
Quality Assurance Manager

Approved by:____
Project Manager

Attachment 1 Boring Log

JE	A BORING LOG	Boring ID No:	Sheet: Of:
		Date Started:	Date Completed:
	Project Name:	Borehole Dia:	
	Project Number:	Drill Type:	
	Location:	Drill Rig and Model:	
Coordinates: N:	E:	Sampling Tool:	
Ground Elevation:		Drilling Company:	
Depth to Static Water:		Name of Driller:	
Depth to First Water:		Geologist:	
Total Depth of Boring:		LTC Code:	LTR Code:

DEPTH (ft bgs)	BLOW COUNTS / CORE RUN	RECOVERY	SAMPLE ID OR CONTROL NO.	PID/FID (ppm)	USCS CLASS.	LITHOLOGY	DECRIPTION OF MATERIALS (MAJOR LITHOLOGY Secondary Components, color, grain size, sorting, grain shape, other lithologic components, sedimentary structures/bedding, consistency or relative density and moisture)	REMARKS
B	C	D	E	F	G	H	I	J

Attachment 2 Key to Logs (Unified Soil Classification System)

KEY TO LOGS

UNIFIED SOIL CLASSIFICATION SYSTEM				
Major Divisions				**Typical Names**
Coarse Grained Soils More Than Half Is Larger Than Number 200 Sieve	Gravels More Than Half Coarse Fraction Is Larger Than Number 4 Sieve	Size Clean Gravels With little Or No Fines	GW	Well graded gravels, gravel-sand mixtures
			GP	Poorly graded gravels, gravels-sand mixtures
		Gravels With Over 12 % Fines	GM	Silty gravels, poorly graded gravel-sand-silt mixtures
			GC	Clayey gravels, poorly graded gravel-sand-clay mixtures
	Sands More Than Half Coarse Fraction Is Smaller Than Number 4 Sieve	Clean Sands With Little Or No Fines	SW	Wellgraded sands, gravelly sands
			SP	Poorly graded sands, gravelly sands
		Sands With over 12% Fines	SM	Silty sands, poorly graded sand-silt mixtures
			SC	Clayey sands, poorly graded sand-clay mixtures
Fine-Grained Soils More Than Half Is Smaller Than Number 200 Sieve	Silts And Clays Liquid Limit 50 % Or Less		ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity
			CL	Inorganic clays of low to medium plasticity, gravelly clays sandy clays, silty clays, lean clays
			OL	Organic clays and organic silty clays of low plasticity
	Silts And Clays Liquid Limit Greater Than 50 %		MH	Inorganic silty, micaceous or diatomaceous fine sandy or silty soils elastic silts
			CH	Inorganic clays of high plasticity, fat clays
			OH	Organic clays of medium to high plasticity, organic silts
Highly Organic Soils			PT	Peat and other highly organic soils

GRAIN SIZE

U.S. Standard Series Sieve: 200, 40, 10, 4

Clear Square Sieve Openings: 3/4", 3", 12"

SILTS AND CLAYS	Sand			Gravel		Cobbles	Boulders
	Fine	Medium	Coarse	Fine	Coarse		

0.075mm 0.425mm 2.0mm 4.75mm 19mm 75mm 300mm

SOIL IDENTIFICATION (MINOR CONSTITUENTS)

Trace (tr)	<5%
Trace to Little (tr to ltl)	5-11%
Little (ltl)	12-24%
Some (sm)	25-34%
"Y" ending	35-44%
"And"	45-50%

SYMBOLS

- Bentonite Seal
- In-Situ Soil Backfill
- Cement Seal
- Morie Filter Sand
- Riser Pipe
- Slotted Screen
- Static Water Level
- 1st Water Encountered

ABBREVIATIONS

OVA	Organic Vapor Analyzer
PPM	Parts per Million
FID	Flame Ionization Detector
PID	Photo Ionization Detector
BGS	Below Ground Surface
NR	Not Recorded
NA	Not Applicable
SCH	Schedule
GW	Groundwater
NM	Not Measured

NOTE:
Soil Boring logs produced prior to March 10, 1997 utilize the Wentworth grain size scale. Subsequently, the USCS grain size scale was implemented.

JACOBS

Soil Classification System

Massachusetts Military Reservation
Cape Cod, Massachusetts

Attachment III

lastmodified 04/11/02 printed 04/11/02 by sl L:\M-REPORTS\Soil Classification\CAD\Key_to_Logs.dwg

Attachment 3 Standard Abbreviations for Lithologic Descriptions

STANDARD ABBREVIATIONS FOR LITHOLOGIC DESCRIPTIONS

ABUND	-Abundant	HOR	-Horizontally	SAT	-Saturated
APPROX	-Approximately	LAM	-Laminated	SCATT	-Scattered
BED	-Bedding	LGT	-Light	SD/Y	-Sand/y
BL	-Blue	LSE	-Loose	SEV	-Several
BLDR/S	-Boulder/s	LTL	-Little	SL	-Slightly
BLK	-Black	LYD	-Layered	SLT/Y	-Silt/y
BLSH	-Bluish	LYS	-Layers	SM	-Some
BP/S	-Bedding Plane	LZ	-Lenses	SML	-Small
BR	-Brown	M	-Medium	SPLS	-Samples
BRSH	-Brownish	MASS	-Massive	ST	-Stained
C	-Common	MATL	-Material	STKS	-Streaks
CBL/S	-Cobble/s	MAX	-Maximum	STRAT	-Stratified
CEM	-Cement/ed	MIC	-Micaceous	T	-Tan
CHT/Y	-Chert/y	MIN	-Minimum	TPSL	-Topsoil
CL/Y	-Clay/ey	MINL	-Mineralized	TR	-Trace
CSG	-Casing	MOD	-Moderately	V	-Very
DK	-Dark	MOTT	-Mottled	VAR	-Variable/bly
ELEV	-Elevation	NODS	-Nodules	W	-With
EST	-Estimated	NUM	-Numerous	WD	-Wood
F	-Fine	OCC	-Occasional/y	WEA	-Weathered
FE	-Ferrous	OR	-Orange	WHT	-White
FOSS	-Fossil/iferous	ORSH	-Orangish	WTR	-Water
GR	-Gray	ORG	-Organics	YEL	-Yellow
GRSH	-Grayish	POSS	-Possible/bly	YELSH	-Yellowish
GRN	-Green	PROB	-Probable/bly	ZN/S	-Zone/s
GRNSH	-Greenish	RD	-Red		
GRND	-Grained	RDSH	-Reddish		
GVL/Y	-Gravel/l	REF	-Reference		
HD	-Hard	RK	-Rock		
		RTS	-Roots		

Attachment 4 Description of Sorting for Unconsolidated Sedimentary Materials

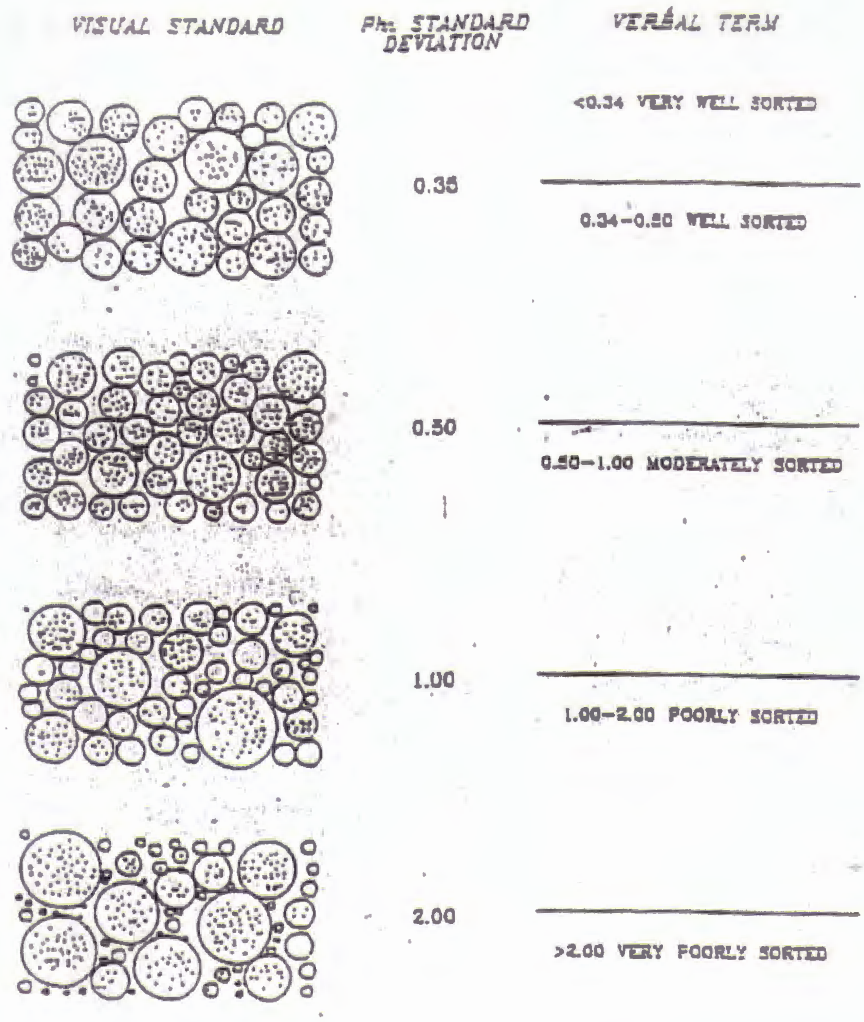


FIG. 4. DESCRIPTION OF SORTING FOR UNCONSOLIDATED SEDIMENTARY MATERIALS
(Folk, 1963)

Attachment 5 Comparison Chart for Estimating Percentage Composition

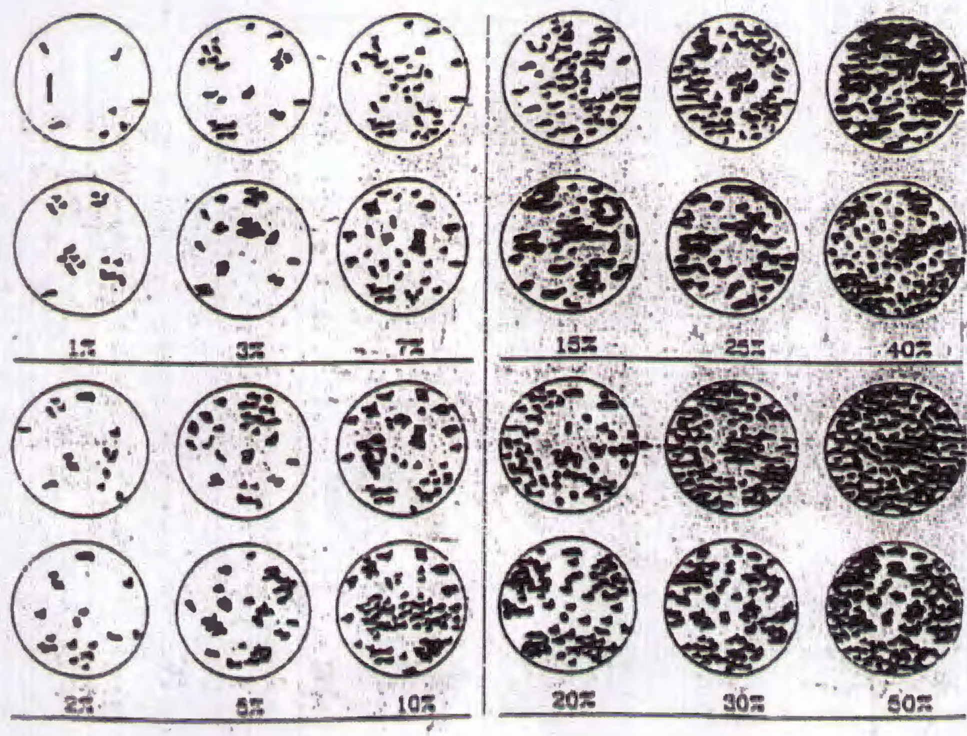


FIG. 2. COMPARISION CHART FOR ESTIMATING PERCENTAGE COMPOSITION

Attachment 6 Particle-Shape Reference Guide

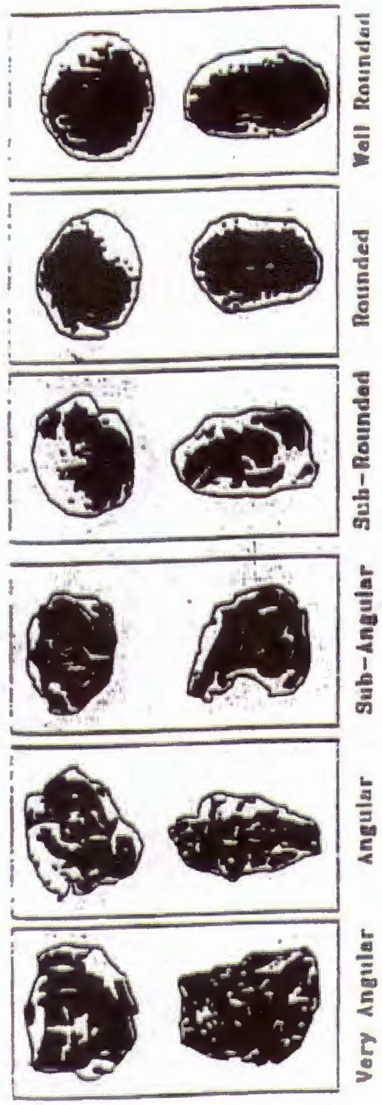
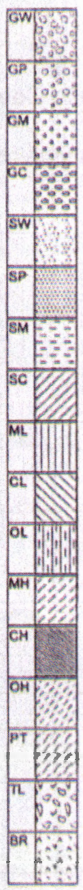


FIG. 3. PARTICLE-SHAPE REFERENCE GUIDE
Compton R.R., 1962

Attachment 7 Lithologic Symbols

Lithologic Symbols



GW	Well graded gravels, gravel-sand mixtures
GP	Poorly graded gravels, gravel-sand mixtures
GM	Silty gravels, poorly graded gravel-sand-silt mixtures
GC	Clayey gravels, poorly graded gravel-sand-clay mixtures
SW	Well graded sands, gravelly sands
SP	Poorly graded sands, gravelly sands
SM	Silty sands, poorly graded sand-silt mixtures
SC	Clayey sands, poorly graded sand-clay mixtures
ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity
CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
OL	Organic clays and organic silty clays of low plasticity
MH	Inorganic silty, micaceous or diatomaceous fine sandy or silty soils, elastic silts
CH	Inorganic clays of high plasticity, fat clays
OH	Organic clays of medium to high plasticity, organic silts
PT	Peat and other highly organic soils
TL	Till
BR	Bedrock

JACOBS ENGINEERING

Attachment 8 Sediment Core Log

Sediment Core Log

Core Location ID	________	A	Water Depth (feet)	______
Geologist/Scientist	________	B	Water Surface Elevation (feet NGVD 29)	______
Collection Method	________	C	Length of Coring Assembly (feet)	______
Date	________	D	Water Surface to Top of Coring Assembly (feet)	______
Time		E	Length of Sediment Core (feet)	______

F Elevation of Bottom of Core (NGVD 29): B-(C-D) ________

G Elevation of Sediment Water Interface Relative to Core Bottom (NGVD 29): F+E ________

H Elevation of Sediment Water Interface Relative to Water Depth (NGVD 29): B-A ________

Elevation (NGVD)	Core Diagram	Lithology - USCS code	Type	Color	Consistency	Odor	Comments

GROUNDWATER PURGING AND SAMPLING PROCEDURE
Low-Flow and Standard Method

1.0 PURPOSE

The purpose of this technical procedure is to describe the methodology for collecting groundwater samples in the field using the low-flow purge/sample and standard three-well volume purge methods. Rev 4

2.0 SCOPE

This procedure applies to all Jacobs personnel and subcontractors who purge groundwater monitoring wells and collect groundwater samples.

3.0 REFERENCES

1. U.S. Environmental Protection Agency (EPA). 1996. EPA Region I Low Stress (Low Flow) Purging and Sampling Procedure for the Collection of Ground Water Samples From Monitoring Wells. July 30, 1996.
2. AFCEE (Air Force Center for Environmental Excellence). 2000 (September). *Quality Program Plan*. AFC-J23-35Q85101-M3-0002. Prepared by Jacobs Engineering Group Inc. for AFCEE/MMR, Installation Restoration Program, Otis Air National Guard Base, MA.

4.0 DEFINITIONS

1. <u>Groundwater</u>: water in a saturated zone or stratum beneath the surface of land or water.
2. <u>Purging</u>: removing stagnant groundwater standing in a monitoring well to allow replacement by fresh formation groundwater.
3. <u>Custody</u>: physical control of an object, in this case an environmental sample.
4. <u>Sample Custodian</u>: the individual who has control of the sample. Rev 4
5. <u>Chain-of-custody record</u>: documentation of the chain of custody showing times, dates, and names of the individuals initiating, relinquishing and receiving the samples identified on the record.

5.0 GENERAL

To obtain representative groundwater samples, disturbances of the natural water column should be kept to a minimum. This is achieved by minimizing the turbulence in the well. Low-flow pumps to purge and sample monitoring wells minimize physical disturbance (turbulence) at the sampling point and chemical changes (aeration) in the medium. For the purposes of this procedure, "low-flow pumps" are defined as either dedicated bladder pumps or variable speed submersible pumps. Practical operational flow rates for these sampling devices range from 0.1 L/min to 30 L/min. Only if low-flow procedures are not possible or practical will another method within this procedure be used. Rev 4

Rev 4

6.0 RESPONSIBILITIES

6.1 Project Manager

The *Project Manager* shall identify and report wells with known or suspected high levels of contaminants to the Sampling Manager.

6.2 Sampling Manager

The *Sampling Manager* shall ensure that the samples obtained represent the environment being investigated. Trace levels of contaminants from external sources will be eliminated through the use of good sampling techniques and the proper sampling equipment.

6.3 Sampling Coordinator

The *Sampling Coordinator* shall ensure that all field crews are provided with the necessary information to successfully complete scheduled sampling (i.e., location ID, well depth, screen length, type of well head completion, and selected analyses). The Sampling Coordinator shall also report groundwater sampling deviations to the Sampling and Project Managers. Rev 4

6.4 Field Team Leader

The *Field Team Leader* (FTL) shall ensure that specified sampling procedures are followed, samples are labeled, handled and controlled correctly, and strict chain of custody is initiated, maintained, and documented.

7.0 PROCEDURE

7.1 Supplies and Equipment

7.1.1 Major Equipment Items

- variable-rate submersible pump/hose assembly with control unit, electrical generator, grounding rod, and extension cord Rev 4
- gasoline and oil (for generator)
- soapy water containers
- potable water containers
- ASTM Type II reagent-grade water containers Rev 4
- purge water drums.

7.1.2 Equipment Support Items

- trash bags
- low phosphate detergent, such as Alconox or Liquinox
- gloves (nitrile)
- 5-gallon bucket
- graduated cylinder Rev 4
- funnel
- drum labels
- folding chairs and table
- Kim wipes/towels

Rev 4

- calculator
- caution tape
- stopwatch
- compass
- polyethylene plastic sheeting.

7.1.3 Sampling Supplies

- written description of wells, including identification numbers, locations, elevations and well construction details
- applicable property gate and well keys
- sample containers (e.g., 40-mL VOA vials, 1-liter plastics, 250-mL ambers, etc.) Rev 4
- chain-of-custody forms
- sample labels
- 0.45-micron filters (for dissolved metals sampling)
- pH paper Rev 4
- ice chest
- ice for sample preservation
- zip-lock bags
- field logbook
- pen and waterproof permanent marker.

7.1.4 Monitoring Equipment

- electronic water level indicator
- YSI water quality meter with flow-through cell or comparable water quality sampling device with attached pH, temperature, specific conductance, turbidity, dissolved oxygen, and oxidation-reduction potential (ORP) probes. Rev 4
- photoionization detector or flame ionization detector.

7.1.5 Health & Safety Items

- first aid kit and emergency eye-wash kit
- emergency information packet (Health and Safety Plan [HSP])
- fire extinguisher Rev 4
- field radio.

7.2 Field Equipment Decontamination

Rev 4

Proper decontamination between wells is essential to avoid introducing contaminants from the sampling equipment. Before purging or sampling, all pumps and hoses, water level measurement devices, water quality probes, and other sampling equipment shall be decontaminated. If new dedicated equipment is used, it shall be thoroughly decontaminated and rinsed with ASTM Type II reagent-grade water before placement in the well. While decontamination of the pump/hose assembly is performed per technical procedure MMR TECH-036 at a central decontamination area, mobile decontamination supplies (e.g., soapy water containers and ASTM Type II reagent-grade water containers) shall be made available so that all appropriate accessory equipment can be decontaminated in the field. Each piece of purging or sampling equipment shall be decontaminated prior to and between sampling operations. Used solutions shall be placed in the purged well water container for disposal. Purge water and decontamination solutions shall be handled and disposed of as outlined in the Investigation-Derived Materials Management Plan (IDMMP). The procedures specified in the Rev 4

Jacobs technical procedure MMR TECH-036, Equipment Decontamination, and the HSP shall be followed for decontamination of field equipment and for personnel decontamination, respectively. Rev 4

7.3 Instrument Usage and Measurement of Water Quality Parameters

Rev 4

Before going into the field, the FTL shall verify that all field instruments are operating properly.

The PID or FID will be calibrated daily using standard calibration gas as specified by the manufacturer. If instrument readings become erratic during normal operations, recalibration will be conducted. Operating instructions for the PID and FID are detailed in the technical procedure MMR TECH-039.

Rev 4

Field measurements for temperature, pH, turbidity, specific conductance, dissolved oxygen, and ORP shall be made in accordance with Jacobs' procedures and the manufacturer's instructions. The YSI 6820 water quality meter instrument shall be calibrated and calibration information recorded as outlined in technical procedure MMR TECH-011. Rev 4

7.4 Well Purging

The purpose of well purging is to remove stagnant water from the well and obtain a representative water sample from the geologic formation being sampled with a minimum of disturbance to the water column. Using the low-flow purging methodology, the well shall be purged until a minimum of two screen volumes have been removed and field parameters (pH, temperature, turbidity, specific conductance, and dissolved oxygen) have stabilized or until the well is pumped or bailed dry. The well shall be sampled immediately following purging without moving or adjusting the position of the pump. If the well is purged dry, it will be sampled immediately following well recovery. Evacuated well water shall be managed as outlined in the Investigation-Derived Materials Management Plan in the QPP. Necessary precautions shall be taken to prevent spilling potentially contaminated water. The water will need to be containerized and treated prior to discharge.

For standard low-flow well purging, the following procedures shall be performed at each well:

- Don personal protective equipment (PPE) as specified in the HSP. Rev 4
- The condition of the well, concrete well pad, protective posts (if present), and any unusual conditions of the area around the well shall be noted in the field logbook. A well recon form shall be completed if a well's condition needs attention. Any deficiencies encountered shall be reported to the Sampling Coordinator as detected. Rev 4
- Using the PID or FID, check the area around the well for VOC vapors (background reading). This reading shall be recorded in the field logbook.
- Set up and establish the exclusion zone around the work area with caution tape.
- Open the well cap and immediately check for VOC vapors in the well casing. Record this reading in the field logbook. Rev 4
- During purging/sampling, take appropriate readings in the breathing zone with air monitoring equipment (PID or FID) according to the HSP (generally every 30 minutes). Rev 4
- Note if the reference point (measuring point) on the well is present. This is usually an indelible mark or V-notch cut. If this point is missing, **make one** on the north side of the PVC riser pipe. Rev 4

- The depth of the static water level shall be measured with a water level indicator (to nearest 0.01 foot) from the measuring point on the PVC riser pipe. To verify equilibration, an additional static water level measurement shall be taken approximately three minutes after obtaining the first measurement. The water level shall be considered static if two consecutive readings are within 0.01 foot. The procedure shall be to record the first static water level measurement and then the well's total depth before taking the second static water level measurement. This information shall be recorded in the field logbook. Rev 4
- The total depth of the well shall be measured from the same measuring point on the PVC riser pipe with a water level indicator and recorded. It is **critical** that the distance between the water sensor and the end of the water level indicator probe be measured independently and added to each total depth measurement. If the total depth measured is >+/-1 foot from the measurement provided in the database, contact the sampling coordinator. The Sampling Coordinator will communicate total depth discrepancies to the database coordinator. Rev 4
- Slowly and carefully lower the pump into the well casing to the bottom of the well so as to avoid unnecessary agitation of silt. Pull the pump back slowly to position the pump within the middle of the well screen interval (e.g., 2.5 feet above the bottom of the well for a 5-foot screen). Wait at least 10 minutes, before taking and recording a third static water level measurement and beginning the initial purge, to allow suspended material to settle to the bottom of the well again. Rev 4
- Start the pump on the lowest setting. Adjust flow slowly until water discharges. Make adjustments to flow rate to aid in turbidity stabilization. Drawdown should be kept to a minimum, when possible less than 0.3 foot. If the minimal drawdown exceeds 0.3 foot but remains stable, continue purging until indicator field parameters are stable. Using a stopwatch and some type of graduated cylinder, measure the pumping rate. The target equilibrium purging rate should be between 0.1 and 2 liters per minute (100 mL/min - 2000 mL/min). Rev 4
- Monitor the water level, pumping rate, cumulative withdrawal, and field parameters including temperature, pH, turbidity, specific conductance, dissolved oxygen, and ORP every five minutes. These shall be recorded in the field logbook. Rev 4
- A minimum of two screen interval volumes of water must be purged. The volume of water in the well screen interval shall be calculated in gallons, based on the length of the screen and the screen diameter. If the well has a filter pack, the screen volume plus the filter pack void volume shall be used to calculate the required unit volume to be evacuated.

The Well Screen Unit Volume (sv) will be calculated using the following equation:

Well Screen Volume (gal.) = $0.041\,(D_c)^2\,(H_s)$

where D_c = well casing diameter in inches and

H_s = length of well screen interval in feet Rev 4

0.041 = conversion factor

The Saturated Filter Pack Unit Volume will be calculated using the following equation:

Saturated Filter Pack Unit Volume = $0.041\,[(D_B)^2 - (D_C)^2]\,(H_S)P$

where D_B = well boring diameter in inches

D_C = well casing diameter in inches

H_S = length of well screen interval in feet Rev 4

P = 0.30 = effective porosity of gravel pack (dimensionless)

0.041 = conversion factor

Example: For 11-inch diameter borehole, 4-inch casing diameter, filter pack porosity = 0.30, screened interval = 10 feet

Saturated Filter Pack Unit Volume = 0.041 (11^2- 4^2) (10) (0.30) = 12.9 gal

Well Screen Volume = 0.041 $(4)^2$ (10) = 6.6 gal Rev 4

Total Unit Volume = Saturated Filter Pack Volume + Casing Unit Volume = 19.5 gal

2 Unit Volumes = 39 gal

Stabilization of indicator field parameters is used to indicate that conditions are suitable for sampling to begin. Purging is complete only when all required field parameters (temperature, pH, specific conductance, turbidity, and dissolved oxygen) have stabilized and a minimum of two screen interval volumes have been purged. Field parameters are collected using the YSI 6820 following MMR TECH-011 for the set-up, use, and record keeping of all field parameter data. At least six readings are to be recorded. Stabilization is achieved when three consecutive readings are within the following tolerances: Rev 4 Rev 4

- pH values are within ±0.1 pH unit,
- temperature within 3%,
- specific conductance is within 3%,
- dissolved oxygen is within 10% (or ± 0.2 mg/L for DO < 2.0 mg/L), and
- turbidity is within 10% if >10 NTU; ± 1.0 NTU between 5 and 10 NTU; or < 5 NTU. Rev 4

Occasionally parameter stabilization problems occur or structural issues prevent normal sampling. Decisions should be executed in accordance with Attachment I when normal sampling is prevented. These are outlined below: Rev 4

(1) When a monitoring well is pumped dry, before water stabilization criteria have been achieved, the sample shall be collected immediately after a sufficient amount of fluid has reentered the well. Rev 4

(2) When parameter(s) stabilization cannot be achieved the FTL shall utilize the Groundwater Purging and Sampling Decision Flow Diagram (Attachment I) and contact the sampling manager(s) to aid in the handling of these wells. Rev 4 Rev 4

(3) When either well drawdown cannot be maintained at less than 0.3 foot or the well screen interval is deeper than the length of the pump hose (typically greater than 300 feet bgs), a minimum three well volumes of water must be purged as follows: Rev 4

Three-Well Volume Calculation

The total well volume = casing unit volume + the saturated filter pack unit volume.

The Casing Unit Volume will be calculated using the following equation:

Casing Unit Volume = 0.041 $(D_C)^2$ H_{WC}

Where D_C = well casing diameter in inches.
H_{WC} = (well depth (feet) - depth to water (feet))
0.041 = conversion factor

The Saturated Filter Pack Unit Volume will be calculated using the following equation:

Saturated Filter Pack Unit Volume = 0.041 $[(D_B)^2 - (D_C)^2]$ (H_{FP}) (P)

Where D_B = borehole diameter in inches
D_C = well casing diameter in inches
H_{FP} = length of saturated filter pack
P = effective porosity of gravel pack (dimensionless)
0.041 = a conversion factor

Example: For 11-inch diameter borehole, 4-inch casing diameter, filter pack porosity = 0.30, well depth = 50' and depth to water = 20', filter pack length = 10'.

Saturated Filter Pack Unit Volume = 0.041 (11^2-4^2) (10)(0.30) = 12.9 gal

Casing Unit Volume = 0.041 $(4)^2$ (50-20) = 19.7 gal Rev 4

Total well volume = saturated filter pack volume + casing unit volume = 32.6 gal

3 well volumes = 98 gal Rev 4

Once this volume of groundwater has been removed, purging is completed. Collect 6 YSI readings and sample. Rev 4

Note: Well volumes for wells that were constructed with the natural formation as the filter pack media will be calculated using the casing unit volume only. Rev 4

7.5 Sample Collection

Using low-flow sampling procedures, samples for chemical analysis shall be collected immediately following purging without disturbing the pump. For slow recovering wells or wells that were purged dry, the sample shall be collected immediately after a sufficient volume is available. The water quality samples shall be taken from within the well screen interval. The following sampling procedures shall be used at each well:

- Immediately following low-flow purging, the pump will be used to collect the groundwater sample. The pump shall not be moved between purging and sampling. Rev 4
- Identification labels for sample bottles shall be filled out for each well.

- The individual sample bottles shall be filled in the order given below (as applicable): Rev 4

  1. volatile organic compounds (VOCs)
  2. ethylene dibromide (EDB)
  3. semivolatile organic compounds (SVOCs)
  4. metals (inorganics)
  5. inorganic anions
  6. other parameters
  7. field test parameters (pH, specific conductance and temperature).

- VOC sample vials shall be completely filled so the water forms a convex meniscus at the top, then capped so that no air space exists in the vial. Turn the vial over and tap it to check for bubbles in the vial, which indicate air. If bubbles are observed, discard the vial and collect another sample. Rev 4
- Fill containers almost full for SVOCs, inorganics, inorganic anions, and all other analyses. Samples shall be preserved and managed as detailed in the site-specific QAPP. Time of sampling shall be recorded. When collecting samples using preservatives, the pH shall be periodically checked (weekly or per the sampling manager's discretion). This shall be completed prior to sample collection. A small amount shall be poured from each container with preservative (except zero-headspace samples) directly on to the pH strip. For VOCs, this is best accomplished by filling an extra vial during collection, ensuring it is not overfilled, then using pH strips to check that the sample is at or below the maximum pH allowed. This vial shall then be disposed of as PPE. It is <u>never</u> permissible to insert pH strips into a sample container. Rev 4 Rev 4
- After the samples have been collected, immediately place them in an ice-filled cooler to be relinquished to the on-site laboratory or the sample prep and pack coordinator/shipper. Rev 4
- Before decontamination of field equipment (YSI, hoses and water level meter), the well cap shall be replaced and locked. Rev 4
- Prior to leaving the site, field documentation, including the chain-of-custody form, shall be completed.

7.6 Quality Assurance/Quality Control Procedures and Samples Rev 4

Quality Assurance/Quality Control (QA/QC) samples shall be collected prior to (as for trip blanks) or during groundwater sampling according to the site-specific QAPP and will be designated in the task-specific Request for Services (R.F.S.) (technical procedure MMR TECH-069). Rev 4

QA/QC samples shall be assigned unique chain-of-custody control numbers and submitted to the laboratory with the other field samples. Rev 4

7.6.1 <u>Trip Blanks</u> Rev 4

Trip blanks are used to assess potential volatile organic contamination during sample custody in the field and shipment to the receiving laboratory. Trip blanks are submitted with characteristic samples to the laboratory to verify that volatile organic contamination has not occurred from outside influences during sample handling or transport (such as absorption through the septa). Rev 4 Rev 4

One trip blank shall be designated and included with samples for volatile organic analysis in the cooler of one sampling crew per project per day. Trip blanks usually consist of two 40mL VOA vials filled with ASTM Type II reagent-grade water. Sample packaging protocols, as required by clients, laboratories, analytical methods or regulatory agencies, will be followed. The containers for these samples shall be from the same bottle lot as those containers used for the site characteristic samples. Trip blanks shall be prepared by a member of the sampling crew prior to arriving at the field. Sample packing and shipping shall follow technical procedure MMR TECH-028. The trip blanks shall remain unopened until they are received at the laboratory. Rev 4

7.6.2 Equipment Blanks Rev 4

An equipment blank sample is used to determine whether decontamination procedures have been effective. Additionally, equipment blank samples may be used to assess potential contamination resulting from containers, preservatives, or sample handling. Rev 4

An equipment blank sample shall be collected in the field using the decontaminated sampling equipment (pump/hose assembly, YSI with flow-through cell and the appropriate hose[s]) prior to the well sampling operation. A 5- or 10gallon carboy will be filled with ASTM Type II reagent-grade water and brought into the field. In some sampling events, additional carboys will be needed to fill all sampling bottles, depending upon pump length, and the amount of samples to be collected. Rev 4

ASTM Type II reagent-grade water shall be rinsed through the decontaminated sampling apparatus and transferred to the sample bottles. Using low-flow sampling procedures, samples shall be collected immediately after a sufficient volume is available. Rev 4
(See Section 7.5 – Sample Collection)

Equipment blank samples shall be submitted for all the parameters being analyzed for. The equipment blank sample is assigned a unique chain-of-custody control number, stored in an ice cooler, and shipped to the laboratory with the other samples. Equipment blank samples shall be preserved in the same manner as native samples. Rev 4

7.6.3 Field Duplicate Samples

Field duplicate samples are collected to assess the total precision of the data collection event. Rev 4 To maximize the information available in assessing total precision, every effort shall be made to collect duplicate samples from the locations suspected of the highest contaminant concentrations. Field measurements, visual observations, past sampling results and information on site operations may be used to select appropriate locations for duplicate analyses.

Field duplicate samples are collected by repeating the sample collection immediately after the original sample has been collected. Rev 4

The duplicate sample shall be preserved and handled in the same manner as the primary sample and assigned a unique chain-of-custody control number, stored in the same ice cooler, and shipped to the laboratory with the other samples. Rev 4

7.6.4 Matrix Spikes and Matrix Spike Duplicates Rev 4

An extra volume of sample media may be collected during the sampling event for the laboratory to conduct matrix spike/matrix spike duplicate (MS/MSD) analyses. The samples shall be Rev 4 collected in the same manner as duplicate samples and labeled as extra volume samples for MS/MSDs.

7.7 Sample Identification, Handling, and Documentation

Samples shall be identified, handled, and recorded as described in this technical procedure and in accordance with standard sample handling protocols indicated in technical procedure MMR TECH-026. Rev 4

8.0 RECORDS

Field notes shall be kept in a bound field logbook as required by technical procedure MMR TECH-035, Field Logbook. The following information shall be recorded using waterproof ink:

- names of sampling personnel
- weather conditions
- equipment used and identification numbers
- daily health and safety topics Rev 4
- project number and project title
- field logbook number
- site visitors chart
- well and background PID chart
- chain-of-custody control numbers
- location and well number
- date and time of sampling
- sample collector
- site condition(s) upon arrival and departure
- condition of the well (e.g., cover, bolts, lock, cap, outer well casing, etc.)
- type of well (e.g., flush or stick-up completion) Rev 4
- minimum purge required and total volume purged
- pump set depth and well screen interval
- decontamination information
- appropriate static water level measurements, total well depth, and measuring point)
- calculations (e.g., three well volume purge, if applicable, and minimum purge)
- analyses that shall be performed by the laboratory
- equipment calibration information
- method of purging
- purge start/stop times
- pumping rate (if applicable)
- field parameter measurements during purging
- sample volume, type and number of containers
- method of sample collection and sample order
- sample preservation
- sketch of the site(s) indicating sample location(s) Rev 4
- Request For Information (R.F.I.) # (if applicable)
- QA/QC samples collected
- irregularities, problems, or delays
- relinquishment of samples (typically to the sample prep and pack coordinator/shipper or onsite laboratory chemist).

9.0 ATTACHMENTS

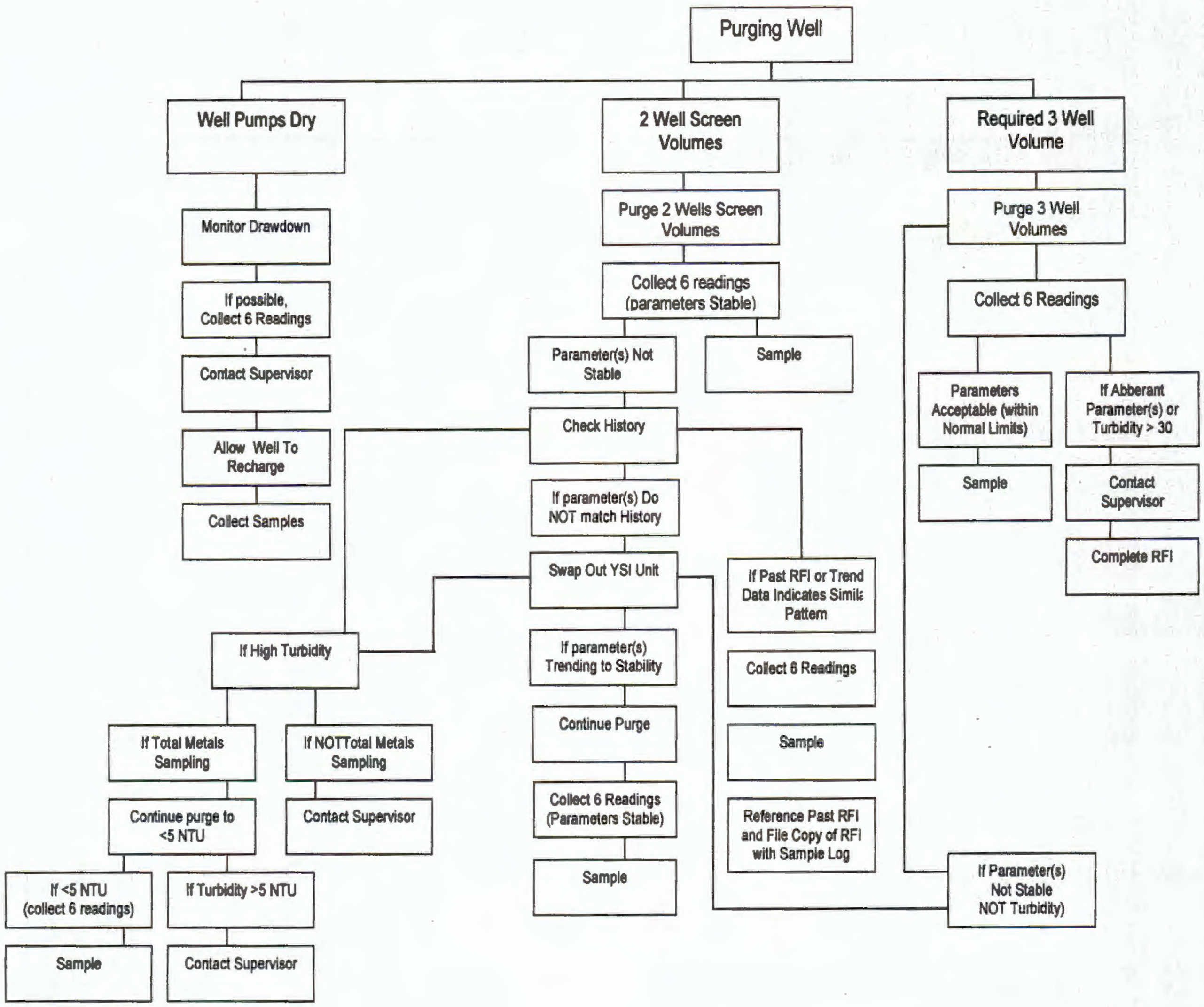
Attachment I - Groundwater Purging and Sampling Decision Flow Diagram

Rev 4

Reviewed by: ______________________________
Quality Assurance Manager

Approved by: ______________________________
Program Manager, Plume Response Program

Attachment I
Groundwater Purging and Sampling Decision Flow Diagram



FIELD FILTRATION OF WATER SAMPLES

1.0 PURPOSE

The purpose of this technical procedure is to provide a filtering method for surface and groundwater samples to be analyzed for dissolved constituents (primarily metals) by separating suspended particulate matter from the substances that are in solution.

2.0 SCOPE

This procedure applies to all Jacobs personnel and subcontractors who perform field filtration of water samples.

3.0 REFERENCES

N/A.

4.0 DEFINITIONS

1. Effluent: the outflow of a treatment system.
2. Influent: the inflow of a treatment system.

5.0 GENERAL

This technical procedure applies to filtration of surface water and groundwater samples in the field during sample collection and before preservation. This procedure is not applicable to groundwater samples containing non-aqueous phase liquids.

The results of a dissolved constituent (primarily metals) analysis of a filtered surface water or groundwater sample are often compared to the results of total constituent analysis from an unfiltered surface water or groundwater sample. From this comparison, a qualitative measurement of the constituents adsorbed onto suspended particles can be made.

Filtration must take place immediately during sampling. The sample should pass from the sampling source through the filter and directly into the sample container.

The unfiltered water sample collected from the same source as the filtered water sample should be collected at the same time as the filtered water sample.

Filtered and unfiltered groundwater samples should be collected immediately after well purging is completed in accordance with site-specific protocols.

The unfiltered water sample(s) will be collected from the same source as the filtered water sample(s). The unfiltered water sample(s) should be collected from the pump or bailer at a point before the water passes through the filter. The same pump or bailer and the same tubing should be used for collecting both the filtered and unfiltered samples. This sampling equipment should not be decontaminated and the tubing should not be changed, cut, disconnected or reconnected except as necessary to connect or disconnect the filter between collecting the filtered and unfiltered water samples.

This technical procedure describes various types of filtering techniques. A peristaltic or submersible pump and an inline 0.45 μm filter is also commonly used. An inline 5 mm filter may also be used prior to the 0.45 µm filter to remove large sediments. The protocols for using peristaltic and submersible pumps are similar. A single peristaltic pump can be used to collect several water samples without decontaminating the pump. However, the pump tubing must be changed between each sample location. It is often cost-effective to dedicate peristaltic pump tubing to a sample location from which filtered water samples are collected periodically, thus allowing the tubing to be reused. Dedicated pump tubing should be decontaminated and stored in labeled, sealed plastic bags between sampling events.

Health and safety precautions including personal protective equipment (PPE) levels applicable to the locations being sampled will be observed.

6.0 RESPONSIBILITIES

6.1 Project Manager

The *Project Manager* is responsible for ensuring overall compliance with this procedure.

6.2 Sample Manager

The *Sample Manager* is responsible for assigning equipment and trained personnel for these tasks.

7.0 PROCEDURE

Field filtration of water samples collected with a bailer may be passed through a barrel filter or a bailer sampling port inline filter; those samples collected with a pump are passed through an in-line capsule filter.

7.1 Sampling Methods

7.1.1 Barrel filter method for use with a bailer

- Equipment:
    1. pressure barrel filter unit
    2. prefilter
    3. 0.45 µm disposable filter
    4. pressure source: pressure bulb, air pump, or nitrogen bottle
- The barrel filter unit and prefilter must be decontaminated prior to filtration of well water. The unit should also be rinsed with well water immediately before filtration.
- The barrel filter unit should be filled with sample water directly from the sampling device (i.e., pump or bailer), being careful to pour directly into the filter reservoir and not around the lip where the O-ring and filter paper rest.
- After reassembly of the unit with prefilter and filter paper in place, turn the unit right side up and connect a pressure bulb, air pump, or nitrogen bottle.
- Place sample bottle under unit and slowly increase pressure as needed to begin flow. Although a barrel filter unit may be rated to 30 psi, 10-15 psi is considered a safe pressure range so as not to cause microfractures in the .45 µm filter.
- If the flow rate is greatly diminished or stopped by a clogged filter, release the pressure from the unit. Disassemble the unit and replace the filter. Reassemble the unit, reattach the pressure source, and resume filtering.
- Decontaminate the filter unit following use according to MMR TECH-036.

7.1.2 Bailer Sampling Port for use with a bailer

- Equipment
    1. bailer bottom emptying device with valve
    2. 0.45 µm disposable inline capsule filters
    3. 4-inch lengths of unused Tygon tubing sized to fit bottom emptying device (one for each sample to be collected)
    4. decontaminated pocket knife
- Fill bailer with sample. The bailer must be full to provide sufficient sample to fill container.
- Attach bottom emptying device to bottom of bailer per manufacturer's instructions (ensure valve is closed).
- Attach one end of 4-inch piece of unused Tygon tubing to bottom emptying device port and the other end to the proper connector on the filter (following flow directions printed on the filter). If necessary, use the knife to pare down the filter connector so that the tubing fits snugly over the end without leaking.
- When container is filled, appropriately dispose of filter and Tygon tubing, as required by the Investigative-Derived Materials Management Plan (IDMMP), and decontaminate bailer, knife, and bottom emptying device before using these again.

7.1.3 Inline 0.45 µm disposable capsule filter for use with a peristaltic pump

- Equipment
    1. disposable inline 0.45 µm capsule filters
    2. approximately three-foot lengths of unused silicon tubing sized to fit pump sampling port (a combination of polyethylene and silicon tubing may be used when longer lengths of tubing are required); one for each sample to be collected.
    3. decontaminated knife
- The 0.45 mm barrel filter shall be placed into the effluent end of tubing, taking care to insert it into the tubing with the arrow on the filter pointing away from the tubing.
- Place influent end of tubing into sample water.
    - An extra container filled by the same procedure as other samples collected at the location may be used.
    - The tubing may be placed directly into the sample well or surface water location. All requirements associated with procedures such as MMR TECH-015 and MMR TECH-017 must be followed.
- Turn pump on, keep flow to less than 100 mL/min to avoid filter breakthrough.
- When container is filled, preserve as necessary and dispose of filter and tubing as required by the IDMMP.
- If the flow rate is greatly diminished or stopped by a clogged filter, release the pressure from the unit. Disassemble the unit and replace the filter. Reassemble the unit, reattach the pressure source, and resume filtering.

7.1.4 Inline 0.45 µm disposable capsule filter for use with a sampling pump

- Equipment.
    - See groundwater sampling list from MMR TECH-015, Groundwater Sampling.
    - 0.45 mm disposable inline capsule filters.
- Complete purging and collection of all unfiltered samples as required by MMR TECH-015.

- Shut sample collection valve, screw in disposable filter, open valve to a flow of <100mL/min, fill appropriate containers.
- If the flow rate is greatly diminished or stopped by a clogged filter, release the pressure from the unit. Disassemble the unit and replace the filter. Reassemble the unit, reattach the pressure source, and resume filtering.
- Preserve samples as required and dispose of 0.45 mm filter as required by the IDMMP.

7.2 IDM Management

Filters, used tubing, and PPE will be disposed of in accordance with the IDMMP.

8.0 RECORDS

All documentation will be in accordance with technical procedure MMR TECH-035, Field Logbook.

Reviewed by: ____
Quality Assurance Manager

Approved by: ____
Program Manager, Plume Response Program

SEDIMENT SAMPLING

1.0 PURPOSE

The purpose of this technical procedure is to outline protocols for sampling sediments. This procedure applies to the collection of sediment samples in surface water bodies from areas of deposition, such as harbors, estuaries, streams, rivers, ditches, lakes, ponds, and lagoons.

2.0 SCOPE

This procedure applies to all Jacobs personnel and subcontractors collecting sediment samples.

3.0 REFERENCES

1. U.S. Environmental Protection Agency (EPA). 1987. *A Compendium of Superfund Field Operations Methods.* EPA/540/P-87/001.

4.0 DEFINITIONS

N/A.

5.0 GENERAL

When both surface water and sediment samples are to be collected, the surface water sample will be collected first (according to TECH-017), as disturbing the sediment may influence the analytical results of the surface water samples and cause cross contamination.

When collecting sediment samples to be analyzed for volatile organic compounds (VOC) do not pool or homogenize the sample. Slowly decant off any liquid phase and then fill the specified container(s) with the solid, ensuring no head space, or following FSP or method specific sample requirements. Samples for nonvolatile organic and inorganic analyses can be placed in an appropriate collection pan or bowl and homogenized before they are placed in sample containers.

If the person collecting the sediment sample needs to enter the water in order to collect the sample, this should be done downstream of the actual sample location and care must be taken not to disturb the sediment in the location to be sampled.

Wear appropriate personal protective equipment (PPE) as prescribed by the program Health and Safety Plan (HSP).

If sampling from a boat or near water bodies with a depth of 5 feet or more, additional health and safety requirements are required, consult Jacobs site specific Health and Safety Plan.

6.0 RESPONSIBILITIES

6.1 PROJECT MANAGER

The *Project Manager* is responsible for ensuring overall compliance with this technical procedure.

6.2 SAMPLE MANAGER

The *Sample Manager* is responsible for assigning qualified personnel and having required equipment available to sample sediment.

6.3 FIELD SAMPLING PERSONNEL

Field Sampling Personnel are responsible for collecting sediment samples in accordance with this technical procedure and any modifications included in the site-specific plan.

7.0 PROCEDURE

The water content of the sediment may vary greatly. Likewise, the sediments themselves may range from very soft to dense. It may be necessary to use a variety of equipment to obtain the required samples, even at a single site.

7.1 EQUIPMENT (SOME SPECIFICATIONS MAY VARY BASED ON SPECIFIC NEEDS)

- stainless steel, polytetrafluoroethelyne (PTFE), or PTFE-lined sampling tray or bowl;
- stainless steel or PTFE dip sampler, scoops, trowels, spoons, and ladles;
- PVC pipe, 2 inch diameter;
- sand core sediment sampler, liners (optional), and extensions;
- jaw type sampler;
- vibra core sampler, liners, and support equipment;
- piston core sampler assembly and liners;
- sample bottles;
- sample cooler with ice;
- rubber boots/waders;
- plastic sheeting;
- utility knife;
- rope;
- boat (optional);
- PPE (as required in the HSP);
- field notebook with waterproof markers;

- decontamination equipment, as appropriate;
- plastic bucket (for rinse water/solvents, decant, and/or spoils);
- appropriate sample data forms (e.g., COCs);
- clear tape;
- pen, pencil, Magic Marker, etc.;
- sample labels;
- tideboard and clamps;
- GPS;
- paper towels; and
- garbage bag for PPE.

7.2 SAMPLING PROCEDURES, LAND BASED COLLECTION

On arrival at the site, set up and organize sampling equipment near the first (farthest downstream) sample location.

Cut a section of plastic sheet to be placed on the ground to use as a clean staging area for sampling equipment.

Arrange sample containers, sampling equipment, and decontaminated equipment on the plastic sheet. Exercise caution not to step on, or otherwise contaminate this clean working surface

Don PPE in accordance with the site HSP.

Collect surface water sample, if required.

- Collect sediment sample. The preferred methods of collecting sediment samples will be by hand corer or PVC pipe.

7.2.1 Hand Corer Method

Label each sample container properly, cover label with clear tape, fill out appropriate chain of custody information, wipe outside of container with paper towel or Kim wipe, and place in iced cooler.

Ensure that the corers and (optional) liners are properly decontaminated prior to initiation of sampling and between each sample location.

Gently push the corer into the sediment with a smooth continuous motion to a depth of approximately 9 inches.

Twist the corer to detach the sample; then withdraw the corer in a single smooth motion.

Remove top of corer and slowly decant excess water.

Remove the nosepiece and deposit the sample onto a stainless steel, PTFE, or PTFE-lined tray or bowl.

Decant, if appropriate and necessary.

Transfer the sample into sample containers (VOCs first) using a stainless steel laboratory spoon (or equivalent device). The transfer equipment may be disposable to avoid decontamination costs, and the risk of cross-contamination. If specific data quality objectives mandate (except for VOC samples), the sample shall be homogenized in a bowl using sampling spoon prior to placement into sample containers.

Decontaminate equipment for the next sample location or at the conclusion of all sampling.

7.2.2 PVC Pipe Method (for very soft sediments only)

Label each sample container properly, cover label with clear tape, fill out appropriate chain of custody information, wipe outside of container with paper towel or Kim wipe, and place in iced cooler.

Gently push pipe into sediment with a smooth continuous motion to a depth of approximately 9 inches.

Cap the pipe, forming an airtight seal, to create a vacuum as it is withdrawn from the sediment.

Slowly decant excess water.

Deposit the sample onto a stainless steel or PTFE tray or bowl.

Decant if appropriate and necessary.

- Transfer the sample into sample containers (VOCs first) using a stainless steel laboratory spoon (or equivalent device). The transfer equipment may be disposable to avoid decontamination costs, and the risk of cross-contamination. If specific data quality objectives mandate (except for VOC samples), the sample shall be homogenized in a bowl using sampling spoon prior to placement into sample containers.

Decontaminate equipment.

7.2.3 Ponar Dredge Method, Boat Based Collection

A Ponar dredge can be used to collect sediment samples from deep water impoundments or flowing streams. This type of sampler has a jaw-type mechanism that is tripped from above in order to close the jaws and collect the sample. The dredge is lowered slowly through the water to the sediment with the jaws in the open position. As the dredge is retrieved, the jaws close and the isolated sediment is brought to the surface.

Pre-weighed VOA, VOC Sediment Sampling:

1. Obtain the sediment sample using the Ponar as described above.
2. Using the supplied syringes, quickly remove approximately 5-10 ml of sediment from the Ponar and transfer it to the provided pre-weighed 40 ml vial.
3. Repeat step 2 to fill the second vial.
4. Fill the 2 ounce jar for percent solids.
5. Record the volume used for each sample in your logbook as well as on the chain-of-custody (COC).

Note: Do not apply tape on pre-weighed VOA vials, but on the outside of the bag.

Decant if appropriate and necessary.

Deposit the Ponar contents onto a stainless steel or PTFE (Teflon) tray or bowl.

- Transfer the sample into sample containers using a stainless steel laboratory spoon (or equivalent device). The transfer equipment may be disposable to avoid decontamination costs, and the risk of cross-contamination. If specific data quality objectives mandate (except for VOC samples), the sample shall be homogenized in a bowl using sampling spoon prior to placement into sample containers.
- Label each sample container properly, cover label with clear tape, fill out appropriate chain of custody information, wipe outside of container with paper towel or Kim wipe, and place in iced cooler.

Decontaminate equipment.

7.2.4 Scoop, Trowel, Spoon, or Ladle, Sampling Method

Label each sample container properly, cover label with clear tape, fill out appropriate chain of custody information, wipe outside of container with paper towel, and place in iced cooler.

Insert the sampling device into the sediment at the selected sampling point and slowly remove the sample.

Slowly decant excess water.

Deposit the sample into a stainless steel or PTFE tray or bowl.

- Transfer the sample into sample containers (VOCs first) using a stainless steel laboratory spoon (or equivalent device). The transfer equipment may be disposable to avoid decontamination costs, and the risk of cross-contamination. If specific data quality objectives mandate (except for VOC samples), the sample shall be homogenized in a bowl using sampling spoon prior to placement into sample containers.

Decontaminate equipment prior to collecting sample from next location.

7.2.5 Piston Core Sampling Method, Boat Based Collection

A piston core sampler is effective in collecting sediment core samples from soft to moderately firm sediments. This type of sampler is limited in depth by the length of tool handle extensions attached. The piston core method relies on suction generated by a piston inside the polycarbonate core tube. The tube is placed on the surface of the sediment and a rope attached to the piston is pulled as the tube is pushed into the sediment. Pushing the tube and pulling the piston drives the tube into the sediment, the suction aids in retaining the sediment core.

Sediment core collection:

- Load a clean polycarbonate tube into sampler and secure.
- Attach rubber piston to rope which is threaded through tube, piston is seated at bottom of tube.
- Measure length of entire coring assembly, record.
- Slowly lower assembly into water vertically until bottom of coring tube just sits on sediment water interface, measure amount of assembly above water, and record.
- Gently pull rope attached to piston until just taut, tie off rope to boat cleat, this pulls the rope at the same rate as which corer is pushed into sediment.
- Slowly push corer into sediment until refusal or desired depth is attained.
- Measure length of assembly above water and record.
- Measure water depth and record.
- Untie rope, slowly pull assembly vertically to surface.
- Keep bottom of coring tube underwater until an assistant can cap bottom of coring tube to retain sediment.
- Remove tube from coring tool, core should remain vertical to prevent mixing of unconsolidated materials.
- Cut a slot in coring tube just above top of sediment in core, drain off excess water slowly.
- Measure length of sediment core and record.
- Measure water surface elevation with survey grade GPS or tideboard and record.
- Cut tube at slot, cap top of tube, rinse exterior, dry, and tape both caps well. With an indelible marker identify the top of the core and core ID on the tube. Store core vertically on ice until further processed.

7.2.6 Vibra Core Sampling Method, Boat Based Collection

A vibra core sampler has the ability to collect a core sample from many types of sediment in water up to 30 feet deep, additional equipment may allow deeper cores to be collected. Vibra core samplers rely on high frequency oscillations to fluidize a thin layer of material in contact with the core barrel, gravity then allows the core barrel to penetrate into the sediment. The vibratory head of a vibra core sampler may be pneumatic, electromechanical or hydraulic. The vibra core sample is collected in either an HDPE flexible liner or a rigid polycarbonate liner; the liner prevents sample contact with the core barrel and retains sediment stratigraphy during collection.

- Measure length of coring assembly and vibratory head, and record.
- Load core barrel with liner.
- Attach core catcher to end of core barrel, secure with pop rivets.
- Measure depth of water at coring location and current time, and record.
- Lower unit vertically into water until core catcher tip is at sediment water interface. Measure and record length of assembly above water surface.
- Energize vibratory head and allow unit to slowly descend into sediment, maintain verticality.
- Once unit has attained desired penetration or has reached refusal de-energize vibratory head. Measure length of coring assembly above water surface, record.
- Lift assembly back to surface, rinse any exterior sediments from core barrel.
- Remove core catcher and pull core liner several inches out of core barrel. Secure end of liner. Rigid liners are secured with a cap and several turns of electrical tape, flexible liners are secured with a set of wire ties.
- Remove liner and core from core barrel. If there is excess water in liner cut a slit just above top of sediment and allow to slowly drain. Trim rigid liner with hacksaw to top of sediment, cap in similar manner to bottom of core. Secure flexible liner top with set of wire ties, trim excess liner above ties if necessary.
- Measure length of sediment core, clearly mark liner to identify top of core and location ID.
- Measure water surface elevation with survey grade GPS or tideboard.
- Store rigid liner cores vertically until processed to prevent mixing, cores collected in flexible liners must be stored horizontaly. Store all cores on ice until processed.

7.3 INVESTIGATIVE-DERIVED MATERIAL (IDM)

Dispose of all sampling waste and PPE in properly labeled containers in accordance with the IDM management plan of the project Field Sampling Plan.

7.4 DECONTAMINATION

All sampling equipment shall be decontaminated before each use and between each location in accordance with technical procedure TECH-036, Equipment Decontamination Procedures.

8.0 RECORDS

All field notes shall be documented in accordance with technical procedure TECH-035, Field Logbook. For all samples, mark the sampling location on a site map. Photograph (optional but recommended) and describe each location, and record sampling location with GPS. If GPS is not immedietly available a stake may be used to mark location unitl GPS is available. The photographs, description and coordinates must be adequate to allow the sampling station to be relocated at a future date.

Reviewed by: ____

Quality Assurance Manager

Approved by: ____

Project Manager

PROCEDURE FOR SONIC WATER AND SOIL SAMPLING

1.0 PURPOSE

The purpose of this technical procedure is to provide guidance for field investigations that use a sonic drill rig. The sonic drill rig can be used to take lithologic samples, water samples, and both lithologic and water samples from the same borehole; it can also advance casing without sampling.

2.0 SCOPE

This technical procedure applies to all Jacobs personnel and subcontractors who use sonic drill rigs.

3.0 REFERENCES

1. Taylor, Theodore and Michael Serafini. 1988. "Screened Auger Sampling: The Technique and Two Case Studies." *Groundwater Monitoring Review* (Summer): 145-152.

4.0 DEFINITIONS

1. Sonic Method: a drilling technique in which the drill string is advanced using vibrations at a frequency of 50 to 150 hertz or cycles per second.
1. Heave: sands and silts that have risen up into the casing. Heave is caused by an imbalance in hydrostatic head. | Rev. 2
2. Purging: activity in which water below the inflated packer and within the interval of the stainless steel sampling screen is removed to allow replacement by fresh representative formation water for sampling.
3. Packer: a hollow cylindrical rod attachment with inflatable rubber siding used to isolate part of the column of water inside the drill casing or borehole.
4. K-Packer: a rubber seal attached to the top of the lead rod to prevent heave from entering the bottom of the drill casing during purging of water.
5. Stainless Steel Screen: a stainless steel screen with machined slots over the entire surface area. The bottom of the screen is closed.

5.0 GENERAL

The sonic drill rig can be a useful tool in a site characterization. The sonic rig setup typically includes the rig and a support vehicle(s) for drilling tools and a water tank. The drill rig and support vehicle should be aligned onsite to allow for safe and easy movement of casing and rods between vehicles. The sonic rig can be used to accomplish four different tasks:

- Drill a burn-down hole in which casing is advanced to depth without sampling.
- Collect water samples at specific elevations within the aquifer.
- Collect lithologic samples at specific elevations within the subsurface.
- Collect lithologic samples and water samples from the same borehole.

The sonic drill does not generate a significant amount of soil cuttings during the drilling operation. The sonic rig is also capable of coring through hard rock.

6.0 RESPONSIBILITIES

6.1 Program Manager

The *Program Manager* shall ensure that the sonic drilling is conducted in accordance with these procedures and the requirements of the appropriate regulatory agencies. Before alternate procedures requested by local agencies, or modifications due to unusual conditions are used, they must be documented and approved by the affected parties; an alternate procedure must also be equal to the procedures of this MMR TECH-024 in terms of the integrity of the collected samples. | Rev. 2

6.2 Project Manager

The *Project Manager* shall develop or direct the preparation of a detailed sampling plan that includes the specifics of the sonic drill rig sampling program. Any approved modifications to this procedure must be documented in an addendum to the procedure. (See Quality Assurance Manager for addendum form.)

6.3 Drilling Manager

The *Drilling Manager* shall ensure that the sonic drill rig sampling procedures comply with this procedure and the sampling plan, and that the field team members are trained in the procedures to be used.

6.4 Field Team Leader

The *Field Team Leader* shall be knowledgeable of the requirements of the sonic drill rig sampling and shall maintain adequate documentation of the procedures and materials used to ensure that the sampling has been properly conducted.

7.0 PROCEDURE

The following procedures shall be followed when using the sonic rig. The procedure will be broken down into the four applicable methods of drilling.

7.1 Burn-Down Hole

The purpose of a burn-down hole is to install a well or nested wells at a specified depth without soil or water sampling. The drilling casing size shall be determined before drilling begins. The casing size will be based on the diameter of the well to be set and the amount of annular fill to be placed. Once the rig is set up, the field geologist shall measure the distance from ground surface to the top of the drilling table. This measurement is made to determine the distance (stick-up) from ground surface to the working platform. Casing advancement can then begin. | Rev. 2

While drilling to the water table, the drilling shall attempt to drill without water, if possible, in order to minimize the amount of water to be purged later. Once the total depth is reached and any heave cleared out of the casing, the bottom of the borehole shall be measured to ensure that the proper depth has been reach. Once the depth has been confirmed, well installation can begin. In a nested setting, the larger diameter drilled casing will be advanced to the desired depth of the upper setting. It should be noted that drillers may prefer to inject mud as a lubricant between the casings. Drilling mud shall not be used within 30 feet above or below a well setting.

7.2 Water Samples

Water samples are typically collected using an electric pump in combination with a packer system to collect water from the bottom of the casing. A common problem with collecting water samples is keeping the formation heave out of the casing. Water pressure is used to hold down the heave. It is required to remove all injected water added during the drilling process. Typically, a laboratory is capable of determining if injected (potable) water is still present in the sample. If injected water is still present, purge volumes must be increased and the packer equipment must be checked to assure that the packer is sealing properly against the casing.

Water samples are typically collected for screening purposes only. Water screening samples help quickly identify plume constituents, concentrations, and area. This information can be used to install a monitoring well for higher quality results. Before screening samples are collected, a set of field parameters for the groundwater will be collected using a YSI meter or similar instrument (MMR TECH-011). Readings can be taken either from a grab sample or collected from a flow-through cell. If a flow-through cell is used, caution needs to be taken to ensure that water visibly high in solids is not used. If the sample interval is producing a high level of solids, a grab sample shall be taken instead of using the flow-through cell. Rev. 2

7.2.1 Materials and Equipment

- Means to measure amount of water injected,
- Source of potable water,
- Pump and packer equipment,
- Hose line and reel for pump discharge,
- Generator to run pump,
- Screen and K-packer,
- Settling/holding tank for purge water,
- Granular-activated carbon (GAC) system,
- Means to measure amount of water purged. Rev. 2

7.2.2 Pre-measurements

- Measure the length of the screen section, the position of the K-packer, and the length of the lead rod. The purpose of this is to know where the screen is and where the pump will rest on top of the lead rod.
- Measure the distance from the bottom of the packer to the bottom of the pump. The information will be used in calculating the amount of water to be purged.
- Measure the length and diameter of hose to calculate volume.
- Both inside and outside casing diameters shall be measured and recorded. Rev. 2

7.2.3 Drilling Activities

Drilling will advance similar to a burn-down hole until the water table is reached. Once the depth to the water table is measured, the casing must be advanced to a depth that allows the pump assembly to be lowered far enough so water will be able to enter the pump intake. It is important to get measurements of the screen and pump assemblies so that the pump can be properly placed to collect the first water sample. Once the outer casing is to a depth appropriate for water sampling, the following steps shall be followed:

- Measure the depth to the bottom of the casing to ensure there is no heave. If heave exists, additional water shall be used to blow heave out. Typically 1 to 2 feet of heave will remain.
- Place the screen and lead rod with K-packer assembly inside the casing. Allow time for the screen to reach the bottom of the casing. Rev. 2
- Retract the casing a predetermined length to expose the screen.
- Re-measure to the top of screen assembly to determine depth of screen. The screen may have moved when the casing was retracted. If the screen remains inside the casing, the screen shall be pulled and the casing reset to the original depth. Rev. 2
- Attach pump and packer assembly to wireline winch and lower to top of the screen assembly.
- Inflate packer. Nitrogen gas or compressed air is generally used to inflate packer to proper psi (psi=0.433 x height of column of water). *It is not necessary to inflate packer if the first zone is at the water table.*
- Make sure lines are properly connected and that the discharge will go through the GAC system or be contained.
- Turn pump on to begin purging. Water will flow from the pumping zone unless (1) the screen is in a no-yield zone, (2) the screen is obstructed, or (3) the pump is not working properly. If no flow occurs, attempt to surge the screen interval. The pump can be pulled to check if operating properly. If the pump is working, the screen is clear, and surging did not induce flow, the zone can be assumed to be a non-yield zone and the casing shall be advanced to the next interval. Rev. 2
- Calculate purge rate—a 5-gallon bucket is typically used.
- Calculate purge time.
- Purge a pre-calculated amount of water. Amount of water to be purged is based on number of well volumes for the water in the casing and the hose (three well volumes), plus the volume of water injected, plus an additional amount of water determined to be needed to get a representative sample of the formation (an additional 10 percent of what was injected).
- Once the appropriate amount of water has been purged, the sample can be collected according to the work plan. If an added sampling port is being used, make sure to purge that line as well.
- Once a sample has been collected, the pump can be turned off, packer deflated, and pump assembly reeled in.
- Lower the quick-connect on the wireline and retrieve the screen assembly.
- Decontaminate the pump and hose line (done by pumping a minimum of 60 gallons through the pump and hose line).
- Advance casing to next interval.
- Repeat process.

If geologic conditions cause slow recharge through the screened interval during the purging process, the purge volumes may be altered to allow sample collection and boring advancement to continue at an efficient rate.

If telescoping casing is used, it is important to not use mud as a lubricant between the casing and the borehole annulus within a distance of 30 feet from the top or bottom of a monitoring well screen zone.

7.3 Lithologic Samples

Lithologic samples can be collected continuously or at specific intervals. Lithologic samples are collected by advancing a core barrel ahead of the casing. The following steps shall be followed when collecting a lithologic sample:

- First, the core barrel shall be advanced to collect the sample. Fluids or air shall not be used during sample collection.
- Once the core barrel has been advanced through the entire sample run, the depth inside the core barrel shall be measured to determine the amount of drilled recovery.
- Next, the casing shall be advanced to the same depth as the core barrel. The top of the core barrel and rods shall be sealed before driving the casing to prevent flushing of the core barrel if water or air is added.
- Retrieve the core barrel to the surface. The core barrel may also be retrieved before advancing the casing.
- Once the top of the core barrel is at the drill table, a second measurement of recovery inside the barrel shall be taken. A comparison with the first measurement will indicate how much has fallen out of the core barrel during retrieval.
- The core barrel can then be raised with the drill head and the sample vibrated out into plastic sleeves. It is important to remember that the first bag out is not going to be the top of the core. Care shall be taken to properly identify each sleeve so that the proper order from top to bottom of the sample can be maintained. | Rev. 2
- A judgment on sample recovery can then be made based on amount of recovery in core barrel, amount in sleeves and any noted losses during transfer from core barrel to sleeve.
- A judgment on appropriate depths for differing stratigraphic units can be made from interpolating recovery measurements, visual observation, soil type, previous sample, drilling response, and/or other experiences if appropriate.
- The core can then be logged according to the boring log procedure (TECH-012).
- Lithologic samples for laboratory analysis can be collected, if indicated by the work plan. Refer to MMR TECH-021. | Rev. 2
- If continuous sampling is desired, the core barrel is put back into the casing and then advanced. If discontinuous sampling is desired, the casing is advanced to the top of the next interval and then the core barrel is inserted.
- Repeat steps.

7.4 Lithologic Samples and Water Samples

Lithologic samples and water samples can be collected by first taking the lithologic sample and then collecting the water sample. This is accomplished by combining the two previous steps in the following order:

- First, the core barrel is advanced to collect the lithologic sample. It is possible to core one or more water sampling intervals before a water sample is collected.
- The casing is then advanced to the bottom of the first interval to be water sampled. The core barrel is then retrieved, and the steps for water sampling are followed.
- Once the sample is collected, the casing can be advanced to the next water sampling depth or set up to take the next lithologic sample, depending on the requirements for the next interval.
- This process is then repeated until the desired borehole depth is reached.

8.0 PURGE WATER TREATMENT

GAC treatment shall be performed as outlined in technical procedure MMR TECH-018. Portable GAC filtration units arranged in series are used to remove low levels of hydrocarbons from purge water. Quality control (QC) samples for field laboratory screening shall be collected after the first unit for every 2,000 gallons of water treated. This is done to measure the effectiveness of the filtration system and to detect contaminant break-through before the effectiveness of the system is diminished. When the first unit is spent, the following unit(s) shall be moved up and a new unit placed at the end.

9.0 DECONTAMINATION

Follow project-specific guidelines for internal and external decontamination of the pump system. (See Attachment I for minimal decontamination guidelines.)

10.0 RECORDS

All field notes will be recorded in accordance with technical procedure MMR TECH-035, Field Logbook.

11.0 ATTACHMENTS

Attachment I – Water and Sampling Equipment Requirements and Guidelines, Decontamination Guidelines

Reviewed by: ______________________________
Quality Assurance Manager

Approved by: ______________________________
Program Manager, Plume Response Program

ATTACHMENT I

Water Sampling Equipment Requirements and Guidelines

Stainless Steel Screen. A stainless steel screen with slots large enough to allow water to flow easily from the formation at a rate that exceeds or matches the submersible pump capacity, yet small enough to prevent fines from flowing in at a rate and size that would damage the pump. A slot size of approximately 0.0006 inch to 0.010 inch is preferable.

Hose, Gas Line, and Electrical Line. All down-hole materials shall conform to project-specific requirements for groundwater sampling equipment. The discharge hose is generally made of PVC. The inflation tubing for the packer is made of high-density polyethylene rated for greater than 2000 psi. The coating on the electrical line for the pump and the ties that hold all three together is Teflon® or another similarly inert material. | Rev. 2

The pump retrieval is relatively simple when the discharge hose, inflation tubing, and electrical line are wound on a large reel that spins freely on a mounted axle near the borehole.

Packer. A pneumatic packer with an inflation diameter of 3.5 to 6 inches shall be used with 4.25-inch hollow-stem augers. (The Tiger Tierra model from Aardvark, for example, meets these requirements.) The packer shall be placed directly above the pump.

Pump. A 4-inch submersible pump capable of pumping 20 gpm shall be used with 4.25-inch hollow-stem augers. (The Gould model 13EM07 meets these requirements.) Remove the check valve, if there is one.

Decontamination Guidelines. These guidelines are offered as a minimal decontamination procedure between borings.

(1) Steam-clean the outside of the pump and associated electrical wires and hose. Also steam-clean anything (e.g., hose reels, pipe racks) that comes in contact with the outside of the hose or pump.

(2) Decontaminate the inside of the pump and hose. Place the pump in a drum of project-approved decontamination water and flush 60 gallons through the pump and hose. If equipment blank samples are required, the sample can be an aliquot of the last of the decontamination water that has run through the pump.

SAMPLE HANDLING AND CUSTODY

1.0 PURPOSE

The purpose of this technical procedure is to delineate protocols for sample handling and custody. An example of the Field Tracking Module (FTM) generated sample label and chain-of-custody (COC) form is provided as part of this procedure (see Attachment A and B). Other formats with identical information are acceptable.

2.0 SCOPE

This procedure applies to all Jacobs' personnel and subcontractors collecting environmental samples.

3.0 REFERENCES

1. U.S. Environmental Protection Agency (EPA), Office of Emergency and Remedial Response, EPA/540/R-96/0, Dec 96 - *Sampler's Guide to the Contract Laboratory Program.*
2. EPA, Office of Emergency and Remedial Response, EPA/540/R-941/013, Feb 94 - *User's Guide to the Contract Laboratory Program.*
3. American Society for Testing and Materials. 1996. Standard Guide for Sampling Chain-of-Custody Procedures. D 4840-95.

4.0 DEFINITIONS

1. Custody: physical possession or control. A sample is under custody if it is in possession or under control so as to prevent tampering or alteration of its characteristics.

2. Sample Label: a record attached to samples to ensure legal documentation of traceability. Attachment A is a copy of the sample labels that are used.

3. Chain-of-Custody (COC) Record: legal documentation of custody of sample materials and instructions for analytical laboratory. Attachment B provides the form used and detailed definitions of the various parts of the form.

5.0 GENERAL

An essential part of the sampling activities of any environmental project is assuring the integrity of the sample from collection to data reporting. Sample labels and COC forms are used to document identification and handling of samples from the time of collection through the completion of chemical analysis. In some projects, analytical data may be used in litigation. Accountability of the history of a sample must be available to demonstrate that the data are a true representation of the environment. The chain-of-custody record is used as evidence in legal proceedings to demonstrate that a sample was not tampered with or altered in any way that may bias the analytical accuracy of the laboratory results. It is extremely important that chain-of-custody records be complete, accurate and consistent.

6.0 RESPONSIBILITIES

6.1 Sample Collector

The *Sample Collector* shall ensure that the samples are correctly collected, labeled, tracked by COC, and stored until they are delivered to the *Sample Shipper*. The *Sample Collector* shall maintain custody of the samples until they are relinquished to the *Sample Shipper*. The *Sample Collector* shall be responsible for informing the *Sample Shipper* of sampling conditions and if any of the samples are potentially hazardous.

6.2 Sample Manager

The *Sample Manager* is responsible for overall compliance and training with this procedure.

6.3 Data Services Manager

The *Data Services Manager* shall assure that the systems are maintained to create COC forms. In addition, the Data Services Manager is responsible for production of COC forms and sample labels for the field crews.

6.4 Sample Shipper

The *Sample Shipper* shall pack the sample shipping coolers, ensure that the COC forms are correct, and ship the samples as described in TECH-028. The *Sample Shipper* shall determine which samples are potentially hazardous and ship them accordingly.

6.5 Field Team Leader

The *Field Team Leader* shall be aware of these procedures and schedule accordingly, taking into account that packing hazardous samples requires more materials (e.g., properly labeled paint cans and manifests) and more time than packing non-hazardous samples.

6.6 Sample Custodian

An individual who is responsible for the custody of samples and completion of associated documentation.

7.0 PROCEDURE

7.1 Sample Custody

Sample custody procedures are designed to ensure that sample integrity is maintained from collection to final disposition. A critical aspect of sound sample collection and analysis protocols is the maintenance of strict chain-of-custody procedures as described in this technical procedure. Chain-of-custody procedures include tracking and documentation during sample collection, shipment, and laboratory processing. A sample is considered to be in an individual's custody if it is (1) in the physical possession of the responsible party; (2) in view of the responsible party after being in their possession (3) secured to prevent tampering; or (4) placed in a designated, secure area that is controlled and restricted by the responsible party.

Custody will be documented throughout all sampling activities on the chain-of-custody record for each day of sampling. This record will accompany the samples from the site to the laboratory. All personnel with sample custody are required to sign, date, and note on the record the time when receiving and relinquishing samples from their immediate custody. Any discrepancies will be noted at this time. Samples will be shipped to subcontractor laboratories via overnight air courier. Bills of lading will be used as custody documentation during this time and will be retained as part of the permanent sample custody documentation. In some cases, samples may be hand delivered to the laboratory; hand delivery will be noted on the chain-of-custody form. The subcontractor laboratory is responsible for sample custody once samples are received.

7.2 Sample Labels

A label will be attached to all sample containers at the time of sample collection. The label will be generated along with the chain of custody form by the *Data Services Manager*. The label will be preprinted with the following information:

- Unique chain-of-custody control number
- Analyses requested
- Preservative used

When the sample collection is complete; the *Sample Collector* fills in the following information in indelible ink:

- Date and time of sample collection
- Sampler's initials.

Once complete; the label will be covered with clear tape and prepared for shipment following TECH-028.

7.3 Chain-of-Custody Record

Chain-of-custody forms will be used to document the integrity of all samples. To maintain a record of sample collection, transfer of samples between personnel, shipment of samples, and receipt of samples at the laboratory, chain-of-custody forms will be filled out for each sample/analysis at each sampling location.

The *Sample Collector* will enter the following information on the COC using indelible black ink:

- Sampler's initials
- Date of collection
- Time of collection (24-hour format)
- Depths, if applicable
- Pump/equipment number, if applicable
- Void reason, if applicable

The Sample Collector shall verify that the COC record is complete, accurate in all aspects, and consistent with all other sample documentation (e.g., number of samples, sample labels, field logs). The Sample Collector will sign the "Collected and Released By" box on the COC record, marking the date and time custody is transferred to the Sample Shipper or other authorized person.

The *Sample Shipper* will perform the following duties:

- obtain the signature of the *Sample Collector* to transfer sample custody
- record the carrier service and airbill number on the COC
- sign and enter the date and time relinquished to the shipper
- prepare the samples for shipment from the field to the laboratory

The Sample Shipper or sample custodian will sign the "Received By" box, marking the date and time of receipt of the samples from the Sample Collector or other sample custodian. Every transfer of physical custody shall be documented on the chain-of-custody record.

Any corrections to the chain-of-custody form entries will be made by a single-line strike mark through the incorrect item, and then entering the correct entry adjacent to the strikeout item. Corrections will be initialed and dated by the person making the change. After the form has been inspected and determined to be satisfactorily complete, the sample shipper will sign, date, and note the time of transferal and will reference a shipper tracking number on the form. The chain-of-custody form will be placed in a recloseable plastic bag and placed inside the cooler after the sample packer has detached the appropriate copy of the form. Field copies of the completed chain-of-custody forms are maintained in project files by the data services group.

7.4 Overnight Sample Storage

In some cases, samples that cannot be shipped immediately to a laboratory must be temporarily stored in a dedicated field sample refrigerator until arrangements can be made for delivery. The sample custodian shall place samples in the refrigerator (samples and signed chain of custody record(s) in Ziploc bags) and secure the refrigerator with a unique, keyed lock, restricting access to one custodian at a time.

Samples temporarily stored in a refrigerator must be received by the custodian that placed them in storage, and in turn, may be "relinquished to" the appropriate laboratory, the Sample Shipper or another sample custodian. Each transfer of custody shall be recorded on the appropriate COC form(s).

8.0 RECORDS

Distribution of the COC record:

- white and canary copies - sealed in plastic bag and taped inside the top of the shipping container
- goldenrod (Field files) and pink copies - submit to Data Services Manager

9.0 ATTACHMENTS

Attachment I - Sample Label
Attachment II - Sample Chain-of-Custody Form

Reviewed by: ______________________________
Quality Assurance Manager

Approved by: ______________________________
Program Manager

ATTACHMENT A

SAMPLE LABEL

Jacobs Engineering
103 Sawyer Street
New Bedford, MA. 02746

Control # **NBH-W052001**
Date: Time:

Analyses:
E504.1 (EDB)
Preservative: 4 deg C

Samplers Initials __________ ____of 2

Jacobs Engineering
103 Sawyer Street
New Bedford, MA. 02746

Control # **NBH-W052001**
Date: Time:

Analyses:
E504.1 (EDB)
Preservative: 4 deg C

Samplers Initial __________ ____ of 2

JE JACOBS ENGINEERING GROUP INC.

CHAIN OF CUSTODY RECORD

USE A BALLPOINT PEN, BLACK INK, AND PRESS FIRMLY. INSTRUCTIONS ARE ON THE BACK

PROJECT NAME:	LABORATORY NAME & ADDRESS:
PROJECT NUMBER:	
WBS CODE: / SUBCONTRACT / P.O. No.	

SAMPLE NUMBER	COLLECTION DATE	COLLECTION TIME	SAMPLER'S INITIALS	NUMBER OF CONTAINERS	CONTAINER SIZE AND TYPE	PRESERVATIVE	MATRIX CODE	ANALYSES REQUESTED	QC	CONDITION ON RECEIPT

COMMENTS:

COLLECTED & RELEASED BY	DATE / /	TIME :	TURNAROUND TIME		
RECEIVED BY	DATE / /	TIME :	RELINQUISHED BY	DATE	TIME
RECORD RETURNED BY	DATE / /	TIME :			
			SHIPPING NUMBER:		

DISTRIBUTION: WHITE – PROJECT FILE / CANARY – LAB RECEIPT / PINK – DATA MANAGEMENT / GOLDENROD – FIELD

INFORMATION IN THIS SECTION FOR JACOBS USE ONLY

LOCATION	SAMPLE TYPE	DEPTH (FT.)	QC CODE

SAMPLING COMMENTS:

FORM-SE.COR 07-10-92

The chain-of-custody provides formal documentation of the possession of samples from the time of collection until received at the laboratory. Internal laboratory custody procedures must be used to document possession of the samples while they are at the laboratory.

To fill out this form, specify the project name, project number, and appropriate WBS code in the box at the upper left-hand corner of the form. In the box to the immediate right, indicate the proper shipping address of the laboratory that is to perform the analysis.

After the form is completed, distribute as follows:

- **White / canary** copies - with samples to laboratory
- **Goldenrod** copy - field files
- **Pink** copy - JEG data management

After laboratory receives the shipment, the box at the lower left, "record returned by," is signed and the white copy is returned to Jacobs. The canary copy is kept by the laboratory for their record.

1) **CONTROL NUMBER**
Enter the Sample Control of the sample.

2) **COLLECTION**
Enter the date (mo/day/yr) and the time (military) of sample collection.

3) **SAMPLER'S INITIALS/CREW**
Enter the initials of the person who collected the sample, followed by the one letter designation of the crew they belong to.

4) **NUMBER OF CONTAINERS**
Enter the number of containers that are grouped together as one sample.

5) **CONTAINER SIZE AND TYPE**
Enter the size/volume and type (VOA, glass, poly, sleeve, etc.) of the container(s). If three 40-mL VOA vials make one sample, the unit size would be 40-mL VOA.

6) **PRESERVATIVE**
Enter the code for the type of preservative used (if the analyses requested does not require preservative, write "none;" all samples are shipped at 4° C):
HNO_3 = preserved with nitric acid
H2S04 = preserved with sulfuric acid
HCl = preserved with hydrochloric acid
NaOH = preserved with sodium hydroxide

7) **MATRIX CODE**
Enter the Matrix code for the matrix samples:
WG = Groundwater SE = Sediment
SW = Surface Water SL = Sludge
WW = Waste Water SO = Soil
LH = Liquid Hydrocarbon GS = Soilgas

8) **ANALYSES REQUESTED**
Enter the analytical method requested. These should be consistent with the work plan/sampling analysis plan for this task (for example, EPA Method 8240, VOA CLP)

9) **QC - REQUIRED**
The sampler must indicate which samples are to have QC analysis performed. Enter the code for the type of QC requested:
S = Single Spiked Sample
M = Matrix Spike/Matrix Spike Duplicate
D = Unspiked duplicate

10) **TURNAROUND TIME (TAT)**
Record the requested TAT (e.g., 30 days, 24 hrs.)

11) **COMMENTS**
This section is used for any additional information that might be useful to the laboratory (e.g., special handling requirements, suspected contaminants, additional compounds to be analyzed, etc.).

12) **COLLECTED AND RELEASED BY**
The person(s) who collected the samples must sign in this area when releasing the samples to sample control. Date and time are as in #2.

13) **CUSTODY BLOCK**
Whenever custody is transferred, the person receiving the samples must sign here. The person releasing the samples must also sign. Date and time are as in #2.

14) **COOLER ID**
Enter a unique one letter identifier for each cooler shipped on a given day. Be sure field QC are shipped **with** appropriate samples.

15) **SHIPPING NUMBER**
Enter the shipping number (e.g., FEDEX airbill number) in the space at the bottom of the form.

16) **LOCATION - ID/FIELD SAMPLE - ID**
First record the location or location code of the exact place the sample was taken (for example S24SB001/OVMW253) followed by the specific sample ID that describes the actual sample (for example S24SB001-0IA or MW253-97Q1)

17) **SAMPLING METHOD**
Enter the type code for the sample taken:
GR = Grab
CO = Composite
UD = Undisturbed

18) **DEPTH**
Enter the number of feet (accurate to 1/10") below the surface the sample was collected.

19) **SAMPLE TYPE**
The Quality Control code is entered whenever field blanks, rinsate blanks, trip blanks, or field duplicates are submitted for analysis (for field duplicates, both samples of the field duplicate pair must be annotated with the proper code):
N1 = Original sample of the field duplicate pair AB = Ambient
EB = Equipment
FD1 = Duplicate samples of N1 TB = Trip Blank

20) **SAMPLING COMMENTS**
This section is for any additional information about the samples that is important but will not affect the laboratory's analysis of the samples. When equipment blanks are collected, indicate what type of sampling equipment (i.e., air/water/soil) was rinsed.

PACKING AND SHIPPING ENVIRONMENTAL SAMPLES

1.0 PURPOSE

The purpose of this technical procedure is to provide a guide for packing and shipping environmental samples with the appropriate chain-of-custody (COC) forms. This is in accordance with all applicable transportation regulations and analytical requirements.

2.0 SCOPE

These procedures apply to all field personnel, including Jacobs and subcontractors involved in the packing and shipping of environmental samples. Samples determined to be hazardous shall be managed in accordance with Jacobs Engineering Corporate Health and Safety Manual SOP, No. 10, "Labeling, Packaging, and Shipping of Hazardous Waste Site Sample."

3.0 REFERENCES

1. U.S. Department of Transportation. 2001 (January). *Code of Federal Regulations*. Title 49, Parts 171 - 180,. Washington, DC.
2. EPA. 2001 (January), Code *of Federal Regulations*. Title 40, Part 261, Section 4. Washington, DC.
3. Dangerous Goods Regulations (International Air Transport Association Regulation 618, Attachment "A"), 43rd edition, 2002.

4.0 DEFINITIONS

1. Absorbent Material: packing material with absorbent capacity, including asbestos-free vermiculite and perlite.
2. *Chain-of-Custody Record:* documentation of the collection and custody of environmental samples, also provides direction to the laboratory for sample analysis.
3. *Courier:* person who maintains personal custody of packaged samples and COC records while delivering the samples from the field to a specified laboratory.
4. Custody: guarded possession of samples.
5. Custody Seals: single use tape used to seal containers.
6. Environmental Samples: samples of air, water, soil, or sediment collected during an environmental investigation.
7. Hazardous Samples: samples that are determined by the field team to be potentially hazardous. These are typically samples from chemical/fuel drums or tanks, samples of sludge or floating product, environmental samples from known areas of concentrated contamination, samples with very high photoionization detector (PID) or lower explosive limit monitor (LEL) readings, or samples that are grossly contaminated (e.g., stained soils).
8. Packing Material: bubble wrap, corrugated paper padding, vermiculite, styrofoam, kitty-litter, and other material used to adsorb moisture or dampen shock during sample shipment.

9. Receipt: acquisition of samples from the person who had custody of the samples.
10. Relinquishment: transfer of sample custody.
11. Shipping Manifest: a Department of Transportation (DOT) document that describes the material being transported, identifies the generator and transporter(s), and instructs the transporter(s) on any special handling requirements.

The shipping manifest serves three primary purposes:

- It serves as a tracking device to trace shipments of hazardous substances.
- It provides information on the contents manifested during transport emergencies.
- It is used by the EPA and the disposal facility for record keeping and reporting on hazardous substance shipping.

5.0 GENERAL

Environmental samples and quality control (QC) samples are collected, labeled, and sealed in the field and custody is maintained as defined in TECH-026, Sample Handling and Custody.

6.0 RESPONSIBILITIES

6.1 Sample Manager

The *Sample Manager* is responsible for overall compliance with this technical procedure.

6.2 Chain-of-Custody Coordinator

The *Chain-of-Custody Coordinator* is responsible for ensuring that all information (labels and COCs) generated are correct.

6.3 Sample Collector

The *Sample Collector* shall ensure that the samples are correctly collected, labeled, tracked by COC, and stored until they are delivered to the Sample Controller or Sample Shipper. The Sample Collector shall maintain custody of the samples until they are relinquished to the Sample Controller/Shipper. The Sample Collector shall be responsible for informing the Sample Controller/Shipper of sampling conditions and if any of the samples are potentially hazardous.

6.4 Sample Shipper

The *Sample Shipper* shall pack the coolers, ensure that the COCs are correct, and ship the samples as described in Section 7.0.

6.5 Sample Coordinator

The *Sample Coordinator* shall determine which samples are potentially hazardous and ship them accordingly.

6.6 Field Team Leader

The *Field Team Leader* shall be aware of this technical procedure and schedule accordingly.

7.0 PROCEDURES

7.1 Determining Sample Status: Hazardous or Environmental

The Code of Federal Regulations (EPA 2001) describes sample shipping requirements. It states that:

> "... a sample of solid waste or a sample of water, soil, or air, which is collected for the sole purpose of testing its characteristics or composition, is not subject to any requirements of this part (hazardous materials shipping requirements)...when:
>
> (i) The sample is being transported to a laboratory for the purpose of testing; or
>
> (ii) The sample is being transported back to the sample collector after testing.
>
> In order to qualify for the(se) exemption(s)..., a sample collector shipping samples to a laboratory and a laboratory returning samples to a sample collector must:
>
> (i) Comply with DOT, U.S. Postal Service (USPS), or any other applicable shipping requirements; or
>
> (ii) Comply with the following requirements if the sample collector determines that DOT, USPS, or other shipping requirements do not apply to the shipment of the sample:
>
> (A) Assure that the following information accompanies the sample:
>
> (1) the sample collector's name, mailing address, and telephone number;
>
> (2) the laboratory's name, mailing address, and telephone number;
>
> (3) the quantity of the sample;
>
> (4) the date of shipment; and
>
> (5) a description of the sample.
>
> (B) Package the sample so that it does not leak, spill, or vaporize from its packaging."

Samples shall be assessed to determine potential hazard. Potentially hazardous samples are required by law to be properly handled and labeled.

Good judgment on the part of the *Sample Coordinator* is also necessary to identify hazardous samples. Samples collected from chemical or fuel drums and tanks, stained or otherwise obviously contaminated soil, free product from a well, leachates, and sludges, are also hazardous samples. Refer the Investigative Derived Materials (IDM) management plan section of the project Field Sampling Plan for guidance on hazardous materials screening and dispositioning.

Hazardous samples must be labeled, packaged, and shipped as hazardous materials per Jacobs the shipper's (Fedex, UPS) requirements.

Samples determined to be non-hazardous by the Sample Coordinator are environmental samples. They are to be labeled, packaged, documented, and shipped as described below.

7.2 Packaging Samples

Determine the maximum allowable weight of each cooler (Federal Express limit is 150 pounds).

Place each container in a zip-lock bag and seal, squeezing as much air as possible from the bag before closing. Glass jars will be wrapped in bubble wrap.

Tape the cooler's drain plug shut on the inside and the outside.

Place approximately 2 inches of material, such as asbestos-free vermiculite or perlite in the bottom of the cooler.

Place a large plastic bag (e.g., trash bag) in the cooler to contain samples.

Place the bottles upright in the plastic bag, with enough room for ice bags to be placed among and around the containers; insulate with enough bubble wrap to deter breakage.

To ensure uniform cooling, place a minimum of three 1-gallon bags of ice (double-bagged) among the containers along the walls and at the top of each cooler. When shipping soil samples, place one bag of ice along the bottom of the cooler as well. For water samples, place the bottles upright in absorbent material to provide additional stability. Do not use "blue ice" as its heat capacity is lower than regular ice. Do not use dry ice. For the receiving laboratory to have an accurate method of assessing the temperature of samples, a temperature blank will be placed in every cooler. Also, additional ice or less samples per cooler will be practiced in order to ensure all samples arrive at the laboratory within the 2° to 6°C temperature range. This practice will be of particular importance during periods of warmer summer like weather.

Custody seal the large plastic bag containing the samples.

Fill the remaining space in the cooler with inert cushioning material (e.g., asbestos-free vermiculite, perlite, beads, or bubble wrap).

7.3 Shipping Samples

If shipping via commercial carrier (e.g., FedEx), write the carrier's name and airbill number on the COC form, place the appropriate pages of the COC form inside a zip-lock bag, and seal the bag with a signed, dated custody seal. The COC has four pages; the top two (white and canary) are sealed inside the zip-lock bag and placed inside the cooler. The pink page goes to project data management, and the goldenrod copy is placed in field files. The COC form sent to the lab must be completed with all designated information; the pages must be originals (not photocopies); and the COC must be unique to the samples contained in the cooler.

If a courier from the laboratory is collecting the samples and delivering them to the lab, have the courier confirm that all samples listed are present and then sign the COC form.

Tape the zip-lock bag containing the COC form to the inside lid of the cooler; close and latch the cooler.

Wrap strapping tape completely around the cooler on both sides of the latch.

Affix "This Side Up" labels on all four sides of the cooler and "Fragile" labels on at least two sides.

Affix the shipping label with the address and telephone number of the laboratory and the Jacobs field office.

Affix signed custody seals on front right and back left of the cooler.

The laboratory shall be notified if the samples are being delivered via courier. The lab must be prepared to receive and check the samples and sign the COC form.

8.0 RECORDS

Instructions for completing COC forms are presented in the technical procedure TECH-026, Sample Handling and Custody.

Reviewed by:

____

Quality Assurance Manager

Approved by:

____

Program Manager

(intentionally blank)

SMALL DIAMETER WELL AND DRIVE POINT GROUNDWATER SAMPLING

1.0 PURPOSE

The purpose of this technical procedure is to describe the methodology for collecting shallow and deep groundwater samples from various types of small diameter wells.

2.0 SCOPE

This procedure applies to all Jacobs personnel and subcontractors with responsibility for water quality determinations and for the collection, preparation, preservation, and submittal of groundwater samples for laboratory analysis. Types of wells include: drive points, piezometers, microwells, and multipoint wells. This procedure will explain site set-up, sampling procedure, and logbook documentation.

3.0 REFERENCES

1. U.S. Environmental Protection Agency (EPA). 1977. *Procedures Manual for Ground Water Monitoring at Solid Waste Disposal Facilities.* EPA-530/SW-611.
2. de Vera, E.R., B.P. Simians, R.D. Stephens, and D.L. Storm. 1990. *Samplers and Sampling Procedures for Hazardous Waste Streams.* EPA-600/2-80-018.
3. Korte, N. and P. Kearl. 1984. *Procedures for the Collection and Preservation of Groundwater and Surface Water Samples and for the Installation of Monitoring Wells.* U.S. Department of Energy, Grand Junction, Colorado.
4. AFCEE. 2000 (September). *Quality Program Plan.* Technical Procedures – MMR TECH-006, 011, 015, 026, 028, 035, 036.

4.0 DEFINITIONS

1. Drive Point: a sampling point installed by pushing a well screen into the ground.
2. Piezometer: a small-diameter stainless steel well monitored for the purpose of measuring water levels.
3. Microwell: a small-diameter well generally installed in water bodies at depths below pond bottom.
4. Multipoint well: a very small-diameter well usually accompanied by other multipoint wells set at varying depths and all encased together.
5. Sampling Equipment: any equipment used during the process of sample collection.
6. Sampling Location: a set location where the sample(s) will be collected.

5.0 GENERAL

Piezometers, microwells, multipoint wells and drive points are installed on land and in or around water bodies for the purposes of monitoring water levels and collecting chemical data from water samples. Similar to monitoring wells, data are obtained by conducting regular sampling and synoptic survey events for various projects. In contrast, piezometers, microwells, multipoint wells and drive points are drilled and constructed differently and have smaller diameters (usually one inch or less) than the standard monitoring well. Due to these differences, sampling methods are different, requiring a separate technical procedure to be followed.

6.0 RESPONSIBILITIES

The *Project Manager* (or designee) shall ensure that appropriate water samples are obtained by providing the Sampling Manager/Coordinator with a request for services.

The *Sampling Manager/Coordinator* is responsible for expediting the request for services and to ensure that qualified personnel are assigned to complete the work. Also, the Sampling Manager/Coordinator is required to communicate problems and/or deviations encountered in the field to the Project Manager.

The *Field Team Leader* (FTL) will lead the sampling team and shall ensure that specified sampling procedures are followed; that samples are labeled, handled and controlled correctly; and that a strict chain of custody is initiated, maintained, and documented.

7.0 PROCEDURE

7.1 Equipment, Materials, and Supplies

- drive-point equipment (post driver or sledge hammer, screened drive point)
- peristaltic pump and battery
- air quality instrument (e.g., photoionization detector)
- YSI water quality instrument and YSI stand
- flow cell apparatus (flow cell, Teflon tubing inflow/outflow connections)
- water level meter or manometer
- table and chairs
- decontamination equipment (deionized water, soapy water)
- other tubing (medical grade silicon, peristaltic tubing)
- purge water containers (e.g., gerry containers)
- 1-liter beaker and funnel
- hip or chest waders (if needed, for any sampling in or around a water body)
- appropriate personnel protective equipment (nitrile gloves, safety glasses, steel-toed boots, and hard hat)
- field logbook and water proof permanent marker
- sample vials, labels, and waterproof permanent maker
- chain-of-custody forms
- cooler with ice for sample preservation
- pH paper
- measuring tape
- stop watch
- a boat, and associated equipment, is required for on-pond microwell sampling.

7.2 Training

The field team leader must, at a minimum, be signed-off on this procedure (MMR TECH-030) by a qualified individual.

7.3 Site Preparation

1. Organize all necessary supplies and equipment.

2. Upon arrival at site, record site conditions. Site conditions are also to be recorded upon departure from site.

3. Set up sampling equipment, materials and site according to Jacob's health and safety policy (exclusions, etc.). For sites requiring boat access, exclusion zones are not required.

7.4 Water Sample Collection Procedures

Proceed with sample collection by following one of the next two water sample collection methods.

7.4.1 Procedure for Water Sampling Using the Water Lift Method

A one-way check valve, such as those produced by Watterra®, shall be used to lift water from the drive point screen to the surface. This method is preferred when collecting samples for volatile organic compounds (VOC) analysis.

1. Obtain initial air monitoring levels upon opening well. Measure initial static water level and total depth.
2. Install the one-way check valve in the Teflon tubing of a length long enough to reach the bottom of the drive point screen and long enough to facilitate convenient dispensing of water into sample bottles.
3. Insert tubing into well.
4. Begin purge by raising and lowering the tubing in the drive point to lift water past the check valve. Containerize all purged water.
5. If possible, allow several liters of water (at least three well volumes) to pass through the system before measuring one set of YSI water quality parameters.
6. Fill a 1-liter beaker with water and then place YSI sonde in beaker and measure one set of water quality parameters.
7. Prior to filling sample containers, confirm container ID with ID recorded in logbook. Sampling can now begin.
8. Collect samples in the proper order as specified in MMR TECH-015.
9. After the samples have been collected, place them immediately in an ice-filled cooler until relinquished.
10. Decontaminate all equipment (YSI meter, Teflon tubing, 1-liter beaker, etc.). Discard silicon tubing and any filters that were used by placing them in a properly labeled PPE bag.
11. Break down the site and record site conditions upon departure.
12. For wells located in water bodies record the following in the logbook:
    - Estimate of depth of water

- Associated staff gauge measurement
- Water level (a manometer is to be used)

If the situation arises where the well is not hydraulically connected to the aquifer an attempt at redeveloping the well shall occur.

- An initial static water level shall be obtained.
- Teflon tubing shall be inserted into the well screen and the appropriate connections for the peristaltic method shall be made.
- If significant drawdown occurs, 3.0 ft. or greater, the well is not hydraulically connected to the aquifer and shall be manually surged. In manually surging the well (using the Watterra® method) there is a potential for redevelopment.
- The water level shall be checked periodically using a small diameter water level meter to ensure that surging the well is in fact clearing the well screen.
- Reconnect the peristaltic tubing to the Teflon tubing.
- Field parameters and sample collection shall occur once the well has recharged.

Rev. 3

7.4.2 Procedure for Water Sampling Using the Peristaltic Pump

Another sampling method is by the use of a portable peristaltic pump. This collection system consists of a peristaltic pump capable of achieving a pump rate of 100 mL/min to 2000 mL/min, and a combination of silicon, polyethylene, and/or Teflon tubing for extending the suction intake. A battery-operated pump is preferable for ease of operation. In this method, the sample is drawn through heavy wall tubing and pumped directly into the sample container. This method is preferred when larger volumes of water are required to be purged. A three well volume purge is required for sampling piezometers, microwells, multipoints, and drive points. Following the purge, six sets of water quality parameters at two-minute intervals are to be recorded before sampling commences. If the well has a filter pack, the saturated filter pack volume plus the casing unit volume shall be used to calculate the required unit volume to be removed. Most small-diameter wells have no filter pack, thus only the casing unit volume needs to be calculated. When a well is pumped dry before the three well volume purge is complete, the sample shall be collected immediately after a sufficient amount of fluid has re-entered the well (after sample collection, if possible, measure one set of water quality parameters).

1. Measure initial air monitoring levels upon opening the well. Measure the initial static water level and total depth.
2. Insert tubing (Teflon or peristaltic) to desired depth. If Teflon tubing is used, connect it to peristaltic tubing and run the peristaltic tubing through the pump.
3. Connect the open end of the peristaltic tubing to the inflow Teflon tubing of the flow-through cell. A small piece of silicon tubing might be needed to connect the peristaltic and Teflon tubing.
4. Connect the inflow Teflon tubing to the inflow port of the flow-through cell. Connect the outflow Teflon tubing to the outflow port of the flow-through cell and insert open end of the tubing into a purge water container (gerry can).
5. Insert YSI sonde into flow-through cell.
6. Turn pump on and begin initial three-well volume purge. Containerize all purge water.

7. After the three-well volume purge, continue purging and measure six sets of water quality parameters at two-minute intervals.
8. Measure the water level at each interval. If limited space in the well will not allow a water level measurement, document as such in the field logbook.
9. Prior to filling sample containers, confirm container ID with ID recorded in logbook. Sampling can now begin.
10. Collect samples in proper order as specified in the MMR TECH-015.
11. After the samples have been collected, immediately place them in an ice-filled cooler until relinquished.
12. Decontaminate all equipment (YSI meter, Teflon tubing, flow-through cell, water level meter). Discard silicon tubing and any used filters by placing them in a properly labeled PPE bag.
13. Break down the site and record site conditions upon departure.
14. For wells located in water bodies record the following in the logbook:
    - Estimate of depth of water
    - Associated staff gauge measurement
    - Water level (a manometer is to be used)

7.5 Completion of Sampling Operation

If the drive point is not to be a permanent installation, remove it. If a vehicle mount hoist is available, it can be used to remove the drive point. Otherwise, a jack may be used to remove the drive point.

For all samples, mark the sampling location on a site map. Photograph (optional but recommended) and describe each location, and place a numbered stake at the sampling location. The photographs and description must be adequate to allow the sampling location to be relocated at a future date.

Dispose of all sampling waste and PPE in properly labeled containers, as required by the Investigation-Derived Materials Management Plan.

7.6 Equipment Decontamination

Prior to sampling and between sampling locations, all sampling equipment (flow-through cell, YSI meter, Teflon tubing), and any other equipment that will be used from one location to the next shall be decontaminated according to the procedures set forth in MMR TECH-036.

8.0 RECORDS

Field notes shall be kept in a bound field log book, following the format specified in technical procedure MMR TECH-035.

Reviewed by: ______________________________
Quality Assurance Manager

Approved by: ______________________________

Program Manager, Plume Response Program

FIELD LOGBOOK

1.0 PURPOSE

The purpose of this technical procedure is to set uniform criteria for the content of field logbooks.

2.0 SCOPE

This procedure applies to all Jacobs personnel and subcontractors who record information in field logbooks.

3.0 DEFINITIONS

1. Representativeness of environmental data describes the degree to which data are a true representation of the conditions existing at a three-dimensional point in space and time.

4.0 GENERAL

An essential part of the sampling portion of any environmental project is proper documentation. The primary document used to record site data is the field logbook. Tasks in which analytical data or conclusions based on analytical data may be used in litigation demand that accountability of the history of a sample be available to demonstrate that the data are a true representation of the environment. The field logbook may be used as evidence in legal proceedings to defend procedures and techniques employed during site investigations. Therefore, it is extremely important that field logbook documentation be factual, complete, accurate and consistent.

5.0 RESPONSIBILITIES

5.1 Project Manager

Each *Project Manager* is responsible for overall compliance with this technical procedure.

5.2 Field Quality Assurance/Quality Control (QA/QC) Coordinator

The *Field Quality Assurance/Quality Control (QA/QC) Coordinator* will be responsible for daily check-in and check-out of logbooks, and will assure that routine (weekly at a minimum) QC checks are performed as logbooks and logbook copies are turned in at the end of each day. The coordinator will also assure that a document control number is issued from the document control coordinator for each logbook.

5.3 Field Team Leader

Each *Field Team Leader* (FTL) is responsible for ensuring that the data entries made in the field logbooks comply with this technical procedure.

5.4 Site Personnel

All *Site Personnel* who make logbook entries are required to read this procedure prior to engaging in this activity. The FTL will advise personnel who will be responsible for field book entries, care and maintenance.

6.0 PROCEDURE

6.1 Preparation

New field logbooks will be obtained as needed from the Field QA/QC Coordinator. The field logbook will be signed out by the individual responsible for its care, and maintained on a daily basis.

Field logbooks will be bound with lined, consecutively numbered pages. All pages must be numbered prior to initial use of the logbook. The following information shall be recorded inside the front cover of the logbook:

- Field Document Control Number
- Activity
- Jacobs Engineering
- Phone Number of ESS trailer where manager is
- Site Contact (Field QA/QC Coordinator)

The first three pages of the logbook will be reserved for a table of contents. The first page will be marked with the following heading:

<u>TABLE OF CONTENTS</u>

Date and Description of Activities	Page
(Start Date)	1 - 5

The remaining pages of the Table of Contents (TOC) will be designated as such with "TOC" written on the top center of each page. The TOC is to be updated on a daily basis at conclusion of activities.

6.2 Operation

The following requirements must be followed when using a logbook:

- The date must be recorded at the top of each page.
- If data collection forms are specified by an activity-specific plan or procedure, the information need not be duplicated, but forms must be referenced in the logbook.
- All changes must be made with a single line through the deletion. Changes must be initialed and dated.
- A diagonal line must be drawn through any space left at the bottom of each page.
- The bottom of each page shall be signed by the author.
- Do not remove any pages from the logbook.

A statement relinquishing ownership of the logbook is to be recorded in the logbook when:

- Another individual takes over operation of the logbook. The exception to this requirement is in the case where the logbook is being shared between members of the field team (see below).
- An individual other than the field crew leaves the site with the logbook in their possession.

The relinquishment statement is to be recorded below the last entry and is to state the person's name that is taking over operation, and is to be signed and dated by the first owner.

A relinquishment statement is not required when:

- A logbook is shared between members of a field team, both acting as logbook operators.
- Another individual does not take over operation, but performs an onsite logbook review only. Examples of this would be reviews in the field by a Health & Safety representative, QA/QC representative, field supervisor, client, client representative, or regulator.

Entries in the field logbook shall be preceded with the time (written in military units). The time should be recorded frequently and at the point of events or measurements that are critical to the activity being logged.

At each station where a sample is collected or an observation made, a detailed description of the location is required. A sketch of the location indicating boring or sample locations is required. The sketch or diagram should be detailed enough for other individuals to locate the points at future times. A direction indicator or compass direction should be included in the sketch. It is preferred that maps and sketches be oriented so that north is towards the top of each page. A wind direction arrow should also be recorded on the sketch.

Events and observations that shall be recorded include but are not limited to:

- Field activity.
- Site conditions (upon arrival and departure).
- Changes in weather that may impact field activities.
- Deviations from procedures outlined in any governing documents. Also record the reason for any noted deviation.
- Problems, downtime, or delays.
- Upgrade or downgrade of personal protective equipment.
- All equipment models and serial numbers used at the site.
- All team members and visitors.
- Health and safety monitoring equipment, including actual and background readings.
- Identification of equipment used, including property or serial ID numbers.
- Start and end times of sampling.
- Decontamination times and methods.

When samples are collected the following shall be recorded:

- Sample location
- Sample number

- Sample methodology
- Sample description
- Sample collector
- Sample depth
- Sample type
- Sample analyses requested
- Sample preservation and confirmation
- Manufacturer and lot number of preservatives
- QC sample numbers and types
- Chain-of-custody number
- Name of individual to whom the samples are relinquished.

6.3 Post-Operation

At the conclusion of each day, the logbook will be returned to the logbook storage cabinet. On a weekly basis, the Field QA/QC Coordinator will perform a QC content check for compliance with this technical procedure.

At the conclusion of a task or when a logbook has been completed, it will be submitted to the Field QA/QC Coordinator for records retention by the document control coordinator.

7.0 RECORDS

Documentation shall follow all guidelines contained in this technical procedure.

Reviewed by: ______________________________
Quality Assurance Manager

Approved by: ______________________________
Program Manager

EQUIPMENT DECONTAMINATION PROCEDURES

1.0 PURPOSE

The purpose of this technical procedure is to provide the step-by-step procedures for field decontamination of equipment. Decontamination of equipment and personal protective equipment (PPE) is designed to ensure that the introduction and transfer of contamination is minimized.

2.0 SCOPE

This procedure applies to all Jacobs personnel and subcontractors collecting environmental samples or operating in environments in which hazardous or contaminating substances are expected to be present.

3.0 REFERENCES

1. EPA. *Procedures to Schedule and Complete Sampling Activities in Cooperation with EPA Region VII Environmental Services Division* (Feb. 1990).
2. EPA Region VII. *Environmental Services Division Operations and Quality Assurance Manual* (Feb. 1, 1991).
3. EPA. *A Compendium of Superfund Field Operations Methods.* Volumes I and II. EPA/540/P 87/001a&b.
4. ASTM. Standard Specification for Reagent Water (D 1193-99)

4.0 DEFINITIONS

1. Decontamination Area: an area that is not expected to be contaminated and is upwind of suspected contaminants.
2. Health and Safety Plan: a plan developed to ensure that all hazards associated with a site are evaluated prior to site entry.
3. Measurement\Monitoring Equipment: any equipment used to check or evaluate site conditions.
4. Potable: acceptable to drink.
5. Sampling Equipment: any equipment used during the process of sample collection.

5.0 GENERAL

Decontamination consists of physically removing contaminants. To prevent the transfer of harmful materials, and to prevent unwanted cross-contamination, certain procedures must be implemented before anyone enters a site.

A decontamination plan should be based on the worst-case scenario (if information about the site is limited). The plan can be modified, if justified by supplemental information. Initially, the decontamination plan assumes that all protective clothing and equipment which leave the exclusion zone are contaminated. Based on this assumption, a system is established to wash and rinse all non-disposable equipment. This procedure will serve as the site decontamination plan.

The type of decontamination procedures and solutions needed at each site should be determined after considering the following site-specific conditions:

- the type of equipment to be decontaminated
- the type of contaminant(s) present
- extent of contamination

6.0 RESPONSIBILITIES

6.1 Project Manager

The *Project Manager* is responsible for ensuring overall compliance with this procedure.

6.2 Drilling/Sampling Manager

The *Site Manager* is responsible for assigning equipment and technicians to perform decontamination tasks.

7.0 PROCEDURE

All sampling equipment used at the site must be decontaminated both before activities begin and after each sample is collected. All drilling equipment must be decontaminated both before activities begin and between each drilling location.

7.1 Decontamination Site

A decontamination area shall be selected or constructed so that decontamination fluids and soil wastes can easily be discarded or discharged into controlled areas. All decontamination liquids shall be treated with granular-activated carbon units prior to discharge.

Smaller decontamination tasks, such as surface water/sediment equipment decontamination, may take place at the sampling locations. In this case, all required decontamination (decon) supplies and equipment must be mobilized to the site.

7.2 Decontamination Equipment

The following is a list of equipment and materials that may be needed to perform decontamination:

- concrete or synthetic material-lined decontamination pad
- brushes, garden-type water sprayers (without oil-lubricated, moving parts), rinse bottles, flat-bladed scrapers
- portable steam cleaner
- sump or collection system for contaminated liquid
- wash tubs and buckets
- materials (potable water, ASTM Type II reagent-grade water, solvents and detergent)

7.3 Decontamination Procedure

7.3.1 Sample Bottles

At the completion of each sampling activity, the outside of each sample bottle must be decontaminated as follows:

- Be sure that the bottle lids are on tight.
- Wipe the outside of the bottle with a paper towel.

7.3.2 Personnel and Personal Protective Equipment

Review the project Health and Safety Plan for appropriate decontamination.

7.3.3 Sampling Equipment

NOTE: See Section 7.3.6 below for groundwater sampling pump decon.

The following steps will be used to decontaminate sampling equipment:

- Decon personnel will wear the appropriate personal protective equipment as required by the site-specific Health and Safety Plan.
- The sequence of actual decontamination will be as follows:
  - Gross contamination of equipment will be scraped off at the sampling site.
  - Water-resistant equipment will be placed in a wash tub of potable water containing Liquinox (non-phosphate), or equivalent laboratory-grade detergent, and scrubbed with a bristle brush or similar utensil.

- Equipment will be thoroughly rinsed with potable water in a second wash tub followed by an ASTM Type II reagent-grade water rinse.
- If equipment has come in contact with oil or grease, rinse with pesticide-grade methanol followed by pesticide-grade hexane.
- If samples will be analyzed for trace metals, rinse with 5% nitric acid. (This rinse should be kept in a separate container for IDM Management.)

- ASTM Type II reagent-grade water shall be stored and dispensed in approved containers.
- Hexane and methanol shall be stored and dispensed in glass, stainless-steel or Teflon containers with Teflon caps or cap liners.
- Depending on site conditions and the number of samples collected at each location, rinse and detergent water will normally be replaced with new solutions between borings or sample locations.
- Following decontamination, equipment will be placed in a clean area on clean plastic sheeting to prevent contact with contaminated soil. All equipment should be allowed time to dry before re-use. If the equipment is not used immediately, it will be covered or wrapped in oil-free aluminum foil to minimize potential airborne contamination.

7.3.4 Measurement Devices/Monitoring Equipment

The pH probe, specific conductance probe, water level indicator, and thermometer will be rinsed with ASTM Type II reagent-grade water before and after each use. Any delicate instrument that cannot be decontaminated easily should be protected while it is being used. These instruments should be covered with plastic sheeting or aluminum foil. Openings should be made in the bag for sample intake.

7.3.5 Bailers

New bailers and nylon rope, which are dedicated for each well and not used for well purging, will only require an ASTM Type II reagent-grade water rinse prior to sample collection. If the bailers are used for purging, they will be decontaminated, as outlined for sampling equipment, before they are used for groundwater sample collection, regardless if a bailer is dedicated for each well. This procedure will be followed to ensure that any contaminants associated with the stagnant water present in the casing prior to purging does not impact the groundwater sample through retention on the bailer. Similarly, if bailers come in contact with the ground or any other potential source of contamination, they will be decontaminated according to the procedure outlined for sampling equipment.

7.3.6 Groundwater Sampling Pumps

Proper decontamination between wells is essential to avoid introducing contaminants from the sampling equipment. The following steps shall be adhered to during decontamination:

- At least two hose volumes of potable water with a non-phosphate detergent such as Liquinox shall be flushed through the pump and then discharged into the containment system.
- Potable water will then be flushed through the pump and over the outside of the hoses for a minimum of one minute to assure that all of the detergent solution has been removed.
- At least two hose volumes of ASTM Type II reagent-grade water shall then be flushed through the pump (two 5-gallon carboys may be used).
- The pump will then be placed in a clean plastic bag and stored in the equipment area.

Note: Wells that historically have high contaminant levels will require additional volumes to be purged through lines (ie..double, triple decon). The Project Manager shall provide a list of high contaminant wells and the appropriate decontamination to Sample Management.

7.3.7 Drilling and Subsurface Soil Sampling Equipment

Drilling equipment and associated materials will be decontaminated by the drilling contractor prior to any drilling operations and between borings. All external surfaces of all drilling equipment (e.g., rigs, tools, drill bits, drilling stem, mud tubs, mud pumps, hoses) will be thoroughly cleaned after each hole is completed. All tools used for soil sampling (e.g., split spoon, split barrel., Hydropunch samplers) will be decontaminated as specified in Section 7.3.3 when collecting analytical data by the drilling subcontractor prior to the collection of each sample. When collecting samples for geotechnical analysis only, sample equipment shall be deconned the same as other drilling tools.

All drilling rigs and tools will be steam-cleaned prior to the commencement of drilling activities. All fluids will be captured and managed as specified in the Investigative Derived Material management section of the Field Sampling Plan (FSP). Decontamination begins by completely removing all soil and visible contamination (e.g., hydraulic fluids and soils) from the equipment with a high-pressure steam cleaner, and thoroughly flushing the interior and exterior of all downhole tools (including drill pipes, collars, bits and tremie pipe) with fresh, clean, potable water.

7.3.8 Decontamination of Heavy Equipment

Heavy equipment (e.g. bulldozers, back-hoes, and trucks) is generally washed with water under pressure, if possible. Portable steam-cleaners and hand washing with a brush and detergent, followed by a potable water rinse, can also be used. Particular care must be given to the components in direct contact with contaminants, such as tires and buckets. Wipe sampling may be utilized to establish effectiveness of decontamination procedures.

7.3.9 Decontamination of Surface Water Sampling Equipment (e.g.,Niskin™Bottle)

Decontamination procedures are essential to avoid introducing contaminants from the sampling equipment. Surface water sampling equipment shall be fully decontaminated between ecosystems (e.g., ponds), but shall be decontaminated with an ASTM Type II reagent-grade water rinse between samples collected within the same ecosystem (within a pond). Under no circumstances shall plastic surface water sampling equipment (e.g., Niskin ™ bottle) be rinsed with solvents which will dissolve the sampling device. Additionally, if the sampling device is to be used for the collection of nutrient samples (e.g., nitrate, nitrite, and ammonia) the sampling device shall not be rinsed with nitric acid.

7.3.9.1 <u>Surface Water Sampling Equipment Decontamination Procedure Between Ecosystems</u>

- Potable water with a non-phosphate detergent such as Liquinox shall be flushed through the Niskin™Bottle and over the outside.
- Using a scrub brush, the entire Niskin™Bottle including the sample port and O-rings shall be thoroughly scrubbed with potable water containing a non-phosphate detergent such as Liquinox.
- Five gallons of potable water with a non-phosphate detergent such as Liquinox will then be drained through the sample port.
- Potable water will then be flushed through the Niskin™Bottle and over the outside. Once thoroughly rinsed, five gallons of potable water shall be drained through the sample port.
- ASTM Type II reagent-grade water shall then be flushed through the Niskin™Bottle and over the outside. Then, five gallons of ASTM Type II reagent-grade water shall be drained through the sample port.
- The Niskin™Bottle will then be wrapped in aluminum foil and stored in the ECO-shed.

7.3.9.2 <u>Surface Water Sampling Equipment Decontamination Procedure Within Ecosystems</u>

This procedure shall be used for decontaminating surface water sampling equipment between samples collected within the same ecosystem.

- Using a deionized water sprayer, thoroughly rinse the inside of the surface water sampler with ASTM Type II reagent-grade water.
- Allow at least 1L of ASTM Type II reagent-grade water to drain through the sampling port of the surface water sampler.

7.4 Investigative-Derived Material

All materials and wastes generated during decontamination will be managed as described in the Investigative Derived Materials management section of the FSP.

8.0 RECORDS

Sampling personnel will be responsible for documenting the decontamination of sampling and drilling equipment. The documentation will be recorded in the field logbooks as per technical procedure TECH-035, Field Logbook. The information entered in the field logbook concerning decontamination shall include the following:

- Decontamination personnel
- Decontamination solutions used
- Date, start and end times
- General decontamination methods and observations
- Equipment identification numbers
- Manufacturer names and lot numbers of decon solutions (methanol, ASTM water, nitric acid).

Reviewed by: ______________________________
Quality Assurance Manager

Approved by: ______________________________
Program Manager

HEADSPACE ANALYSIS FOR VOLATILE ORGANIC COMPOUNDS IN SOILS FOR IDM MANAGEMENT

1.0 PURPOSE

The purpose of this technical procedure is to describe the methodology for performing headspace analysis for volatile organic compounds (VOCs) when delineating soil as Investigative Derived Material (IDM).

2.0 SCOPE

This procedure applies to all Jacobs personnel and subcontractors performing headspace analysis for IDM delineation.

3.0 REFERENCES

1. U.S. Environmental Protection Agency. 1988. *Field Screening Methods Catalog.* Office of Emergency and Remedial Response. EPA/540/2-88/005.
2. Massachusetts Department of Environmental Protection. 1995. *The Massachusetts Contingency Plan, 310 CMR 40.0000.*

4.0 DEFINITIONS

1. <u>Volatile Organic Compounds (VOCs)</u>: a group of organic compounds that evaporate when exposed to air.
2. <u>Photoionization Detector (PID)</u>: detects total concentrations of many organic and some inorganic gases and vapors. Molecules are ionized using ultraviolet radiation; a current is produced in proportion to the number of ions present.
3. <u>Headspace gases</u>: the accumulated gaseous components found above solid or liquid layers in closed vessels.
4. <u>Flame Ionization Detector (FID)</u>: detects total concentrations of organic gases and vapors. Gases and vapors are ionized in a flame; a current is produced in proportion to the number of carbon atoms present.

5.0 GENERAL

Portable screening instruments are used to provide a relative indication of the presence of VOCs and to direct the collection of additional samples or the selection of additional soil borehole locations to tentatively define the extent of VOC contamination. The results may be used to determine which samples will be sent to the laboratory for full or partial analysis of constituents.

6.0 RESPONSIBILITIES

6.1 Project Manager

The *Project Manager* shall ensure that the headspace analysis for VOC procedures comply with these procedures and the requirements of the enforcing agencies.

6.2 Field Team Leader

The *Field Team Leader* shall ensure that the instrument operator has been trained in the calibration and use of the field equipment.

7.0 PROCEDURE

7.1 Equipment

The portable field instruments commonly used for onsite headspace analyses are the Organic Vapor Analyzer (OVA) installed with a Flame Ionization Detector (FID), and the Microtip Photo Ionization Detector (PID). Headspace analyses may be performed using a portable gas chromatograph (GC) with a PID, FID or electrolytic conductivity detector (ELCD). The selection of the instrument to be employed will depend on the following:

- target compounds of interest
- detection limits required
- data quality goals
- applicable methodology
- moisture content of samples

All field analyses provide the advantage of quick-turnaround results that are cost effective. However, limitations do exist and must be considered when selecting a field screening tool.

7.1.1 Microtip Photoionization Detector

The Microtip PID measures total organic vapor concentration; it is not able to identify individual compounds. The response methane is reported as a benzene equivalent. Detection for certain VOCs depends on the bulb type used (i.e., 10.0 electron volt [eV]). *High ambient humidity causes erratic responses*. The detection limit for most VOCs is 100 micrograms per liter (µg/L).

7.1.2 OVA Flame Ionization Detector

The OVA FID measures low molecular weight total volatile organic concentration and specific constituents. Highly volatile organics tend to skew the analysis for total VOCs; therefore, a charcoal filter must be used. Light VOCs are difficult to detect. The response is reported in methane equivalent. Detection limit is 500 µg/L for most VOCs. The OVA uses H_2 gas as fuel.

7.2 Analytical Screening

The following is the recommended procedure for conducting analytical screening of contaminated soil utilizing a PID or a FID:

NOTE: *The PID should not be used to screen samples with a high moisture content.*

(1) Half-fill two clean glass jars with the sample to be analyzed. Quickly cover each open top with one or two sheets of clean aluminum foil and subsequently apply screw caps to tightly seal the jars. Sixteen-ounce (16 oz. = approximately 500 ml) soil or mason type jars are preferred; jars with less than 8 oz. capacity (approximately 250 ml) should not be used.

(2) Allow headspace development for at least 10 minutes. ***Vigorously shake jars for 15 seconds, both at the beginning and end of the headspace development period***. If the ambient temperature is below 32° F (0° C), headspace development should be inside a heated vehicle or building.

(3) Subsequent to headspace development, remove the lid and quickly puncture the foil seal with the instrument probe to about one-half of the headspace depth. Exercise care to avoid uptake of water droplets or soil particulates.

(4) Record the highest meter response as the sample concentration. Using the foil seal/probe insertion method, the maximum response should occur within 2 and 5 seconds. Erratic meter response may occur at high organic vapor concentrations or conditions of elevated headspace moisture; in these cases headspace data should be discounted.

(5) The headspace screening data from both jar samples should be recorded and compared; generally, replicate values should be consistent to plus or minus 20%.

(6) PID and FID field instruments should be operated and calibrated to yield total organic vapors in ppmv (parts per million by volume) as methane or isobutylene referenced to benzene. PID instruments must be operated with a 10.0 +/- eV lamp source. Operation, maintenance, and calibration should be performed in accordance with the manufacturer's specifications. For jar headspace analysis, instrument calibration should be checked and, if necessary, adjusted no less than once every 10 analyses, or daily, whichever is greater.

(7) Instrumentation with digital (LED/LCD) displays may not be able to discern maximum headspace response unless equipped with a maximum hold feature or strip-chart recorder. Deviations, departures or additions to the above procedures should be consistent with State Law 310 CMR (Commonwealth of Massachusetts Regulation) 40.0017. In such cases, compelling technical justification must be presented and documented.

7.3 Decontamination

Jars may be reused after a thorough rinse with potable water when measurements of volatile organic compounds are below background levels. The jars shall be dried with a paper towel or air-dried before reuse.

8.0 RECORDS

All measurement data will be recorded in accordance with technical procedure TECH-035, Field Logbook; the following information will also be recorded:

- site/borehole location
- sample interval
- date and time of soil collection
- time and result of headspace analysis
- analyst's name
- time and result of background measurements
- duplicate sample results
- disposition of headspace media

Reviewed by: ______________________________
Quality Assurance Manager

Approved by: ______________________________
Program Manager

SMALL-DIAMETER (MICRO-WELL) INSTALLATION

1.0 PURPOSE

The purpose of this procedure is to ensure that micro-wells are properly installed using appropriate vibratory hammer techniques.

2.0 SCOPE

This procedure applies to all Jacobs personnel and subcontractors installing micro-wells for environmental investigations and monitoring programs.

3.0 REFERENCES

1. Aller, L., et al. 1989. *Handbook of Suggested Practices for the Design and Installation of Ground-Water Monitoring Wells.* National Water Well Association, U.S. Environmental Protection Agency (EPA). EPA 600/4-89/034.
2. American Society for Testing and Materials. 1994. *ASTM Standards on Ground Water and Vadose Zone Investigations.* D 5092 - 90. 2nd edition. pp. 278-288. ASTM, Philadelphia, PA.
3. Barcelona, M.J., J.P. Gibb, J.A. Helfrich, and E.E. Garske. 1985. *Practical Guide for Ground-Water Sampling.* EPA/600/2-85/104. pp. 47-72.
4. Massachusetts Department of Environmental Protection. 1991. *Standard References for Monitoring Wells.*
5. Driscoll, F.G. 1986. *Groundwater and Wells.* pp. 395-463. St. Paul, MN: Johnson Division.
6. Nielsen, D.M. 1991. *Practical Handbook of Ground-Water Monitoring.* Lewis Publishers.
7. Todd, D.K. 1980. *Ground-Water Hydrology.* 2nd edition. pp. 164-193.
8. U.S. Environmental Protection Agency (EPA). 1991. *Groundwater Volume II: Methodology*, EPA/625/6-90/016b. pp. 1-21.
9. EPA. 1986. *RCRA (Resource Conservation and Recovery Act) Ground-Water Monitoring Technical Enforcement Guidance Document.* OSWER-9950.1. pp. 71-94.

4.0 DEFINITIONS

1. <u>Check valve:</u> a Teflon or stainless steel one-way valve attached to tubing that is used to sample water from desired interval.
2. <u>Drive point:</u> a carbon or stainless steel well point attached to the leading section of a micro-well casing.
3. <u>Micro-well</u>: a small-diameter (less than 1 inch) monitoring well installed for the purpose of extracting groundwater for physical and chemical sampling.
4. <u>Tremie pipe:</u> a pipe with side discharge that carries materials to the bottom of the borehole and allows for placement of materials upward from the bottom.

5. Vibratory hammer: a high-frequency pneumatic hammer that advances the micro-well casing.
6. Well casing: an impervious durable tubular product that is a permanent feature of a well; it is designed to (1) prevent caving of the boring walls, (2) provide access from the ground surface to some point in the subsurface, and (3) serve as a passage for groundwater level measurement and sample collection devices.
7. Well screen: a section of casing that has been slotted to allow for free movement of water into a well.

5.0 GENERAL

Installing a micro-well requires the use of a vibratory drill. In general, this installation technique can be utilized for the completion of micro-wells to provide monitoring locations for long term water quality sampling and groundwater elevation data.

Micro-wells can be installed by a truck or ATV-mounted high frequency vibratory hammer (VH) rig or a hand-held VH. The VH rig shall be trailered to each approved location. The VH rig shall be properly secured prior to any intrusive activities.

The VH vibrates the well casing into the ground; no drill cuttings are returned to the surface. This method eliminates the requirement for drilling fluids, sand pack and annular seals. Soil particles adjacent to the well casing are put in motion and create a fluidized zone around the pipe. Once vibration ceases, the soil particles compact around the well to form a natural seal.

Micro-well installations require that the procedures used for installing each component of the well are followed and well documented. The four essential components of a well installation are:

- installation of well casing and well screen, including drive point and sump
- well development
- surface completion and well protection
- well construction documentation and field logbooks.

6.0 RESPONSIBILITIES

6.1 Project Manager

Each *Project Manager* shall ensure that the well installation procedures used are in compliance with these procedures and the requirements of the enforcing agencies. Alternate installation requirements and procedures requested by local agencies, or modifications due to unusual conditions must be documented, approved by the appropriate parties, and, at a minimum, be equal to these procedures in terms of safety.

The *Project Manager* shall develop or direct the preparation of a detailed sampling plan that includes the specifics of the well installation design, particularly the materials and procedures to be used. A registered geologist or professional engineer and the enforcing agencies shall review and approve the design prior to the beginning of well installation. This procedure must not be re-written for the purposes of the project. Any approved modifications must be documented in an addendum to the procedure (see local Quality Assurance Officer for addendum form).

6.2 Drilling Manager or Environmental Support Services Manager

The *Drilling Manager* or *Environmental Support Services Manager* shall assure that the well installation procedures used are in compliance with the sampling plan and this TECH-064, and that the *Field Team Members* are trained and certified competent in the procedures.

6.3 Field Team Leader

The *Field Team Leader* shall know the requirements for well installations, and shall maintain adequate documentation of the installation process and the materials used to assure that proper well installation has been performed and is defensible.

7.0 PROCEDURE

During the installation of the micro-wells, the following procedures should be followed to ensure proper installation and the integrity of the well.

7.1 Well Casing and Well Screen

7.1.1 Materials

Micro-wells shall consist of approximately 7/8-inch outer diameter mild steel casing and screen. Screen length shall be determined based on the purpose of the monitoring well and aquifer characteristics. To obtain specific information about water quality and hydraulic characteristics, well screens are usually 5 to 20 feet long. The screen slot size standard is 0.010 to 0.020 inches, unless field conditions indicate otherwise and approval of the drilling manager has been obtained.

The project work plan defines the screened interval and screen slot size, and describes the specific material decontamination procedures and requirements. General decontamination procedures are provided in procedure MMR TECH-036. The manufacturer's certifications of cleanliness for pre-cleaned materials must be documented in project files and recorded in field notes. The quantities of well materials used in the well installation (i.e. well casing and screen) must be documented in the field logbook.

7.1.2 Installation Procedures

The following procedures shall be followed when installing well casings and well screens:

- All well casing and screen material shall be assembled and installed with sufficient care to prevent damage to the sections and joints.
- Sections of well casing and screen must be connected by a mechanical method, such as hydraulically crimped external collars or threaded pipe.
- Prior to advancing the well screen, a drive point must be placed at the bottom of the well screen.
- The VH is then used to vibrate the well casing into the ground; no drill cuttings are returned to the surface. Drilling fluids, sand pack and annular seals are not required.
- For truck or ATV mounted VH rigs, several sections of well material can be connected and vibrated into the ground.

7.2 Development Procedures

- Remove silt and sand from the well screen with a peristaltic pump or check-valve type pump before purging well volumes.
- A minimum of three well volumes shall be removed using a peristaltic pump or an applicable check valve method.
- Development water shall be collected and stored in appropriate containers prior to treatment.
- If the micro-well is intended for sampling, refer to MMR Tech 004 for development water sampling goals.

7.3 Micro-well Completion and Protection

Two types of surface completions are typical to micro-well installations: (1) above-ground completion and (2) flush-mounted completion. An above-ground completion is generally preferred. However, a flush-mounted completion may be specified or required in traffic areas. The purposes of surface completions and well protection are to prevent surface runoff from entering the well, and to protect the well from accidental damage or vandalism. Upon completion of the well installation, the micro-well shall be properly surveyed and the measurements documented.

7.4.1 Above-ground Completions

The following procedures shall be followed for above-ground completions.

- The well casing shall extend 2 to 3 feet above the ground surface with a vented end plug or casing cap provided for each well.
- A protective casing will be installed around the well casing by placing the protective casing into the surface seal while still wet and uncured. The protective casing shall be positioned and installed in a plumb position.
- Protective casing must be anchored below the frost depth and extend a minimum of 24 inches above the ground surface.
- Protective casing must be vented to allow for the escape of possible gas buildups and to allow the water levels to respond naturally to barometric pressure changes. Additionally, a drain hole should be placed above the concrete level to allow for draining of any trapped water from installation and sampling of the well. The casing will be painted yellow or another color chosen by the client to be easily observable.
- A weatherproof locking cap shall be installed on the protective casing, ensuring adequate clearance between the top of the well casing and bottom of the locking cap.
- A concrete surface pad (usually 4 inches thick) shall be placed surrounding the well protective casing. The pad shall be sloped away from the protective casing. A ½ round survey pin shall be set on the north side of the concrete pad.
- Well protection posts shall be placed around wells in high traffic areas as required. Usually, 3 or 4 three-inch diameter, concrete-filled, steel posts will be installed. Posts should be placed about two feet below ground surface and should rise a minimum of four feet above ground. The posts should not be placed in the concrete pad. Posts will be painted yellow or another color chosen by the client.
- A well identification tag shall be affixed to the protective casing by riveting the ID tag to the steel casing. Internal ID tags shall be banded to each well casing riser pipe within the protective casing.

7.4.2 Flush-Mounted Completions

The following procedures shall be followed for flush-mounted completions.

- Well casing placed must be cut off below grade, leaving enough space for the placement of an end plug or casing cap at each well.
- A protective structure, such as a utility or Christie valve box assembly, will be installed around the well casing. The valve box shall be freely draining. The protective structure shall be centered in a 3-foot-square concrete pad sloped away from the structure. In areas where plowing is not required, the center of the pad will be approximately 4 inches above the ground surface.
- For flush-mounted completions located in high traffic areas, completion will follow the procedures outlined above except that a traffic-rated cement or steel vault will be used and cemented flush with the traffic surface.
- For these flush-mounted completions, care should be used to ensure that the bond between the protective structure and the cement surface seal, and the protective structure and the removable cover are watertight. Use of expanding cement and flexible gaskets are suggested.
- Where significant amounts of runoff occur, additional protection measures may be required.

8.0 WELL ABANDONMENT

The subcontractor shall grout each well that has been determined to be damaged or inadequate according to the project scope of work. Grout used in construction will be composed of:

- 20 parts cement (Portland cement, type II or V);
- 0.4 to 1 part (max.)(2-5%) bentonite; and mixed with
- 8-gallons (max.) approved water per 94-lb. bag of cement.

Neither additives nor borehole cuttings will be mixed with the grout. Bentonite will be added after the required amount of cement is mixed with the water.

All grout material will be combined in an above-ground container and mechanically blended to produce a thick lump-free mixture. Manual mixing of the grout is not allowed. The mixed grout will be recirculated through the grout pump prior to placement.

Grout shall be placed in the well using a grout pump and tremie pipe. Polyethylene tubing is acceptable as a tremie pipe. Each well shall be grouted to the surface. A temporary cap shall be placed on top of the well.

9.0 INVESTIGATION-DERIVED MATERIAL

All water derived from the installation and sampling of these wells shall be treated by the granular-activated carbon (GAC) system located in the central storage area (CSA). The

Subcontractor shall transport all water to the CSA where he /she will relinquish it to the appropriate JEG employee at the end of each working day.

10.0 RECORDS

All materials and procedures used during installation of the well shall be documented in field logbooks, as detailed in the technical procedure MMR TECH-035, Field Logbooks.

Reviewed by: ______________________________
Quality Assurance Manager

Approved by: ______________________________
Program Manager, Plume Response Program

Appendix C
Example Chain of Custody Form

JE JACOBS ENGINEERING GROUP INC.
[illegible]

CHAIN OF CUSTODY RECORD

USE A BALLPOINT PEN, BLACK INK AND PRESS FIRMLY. INSTRUCTIONS ARE ON THE BACK

PROJECT NAME:	LABORATORY NAME & ADDRESS:
PROJECT NUMBER:	
WBS CODE: SUBCONTRACT / P.O. No.	

SAMPLE NUMBER	COLLECTION		SAMPLER'S INITIALS	NUMBER OF CONTAINERS	CONTAINER SIZE AND TYPE	PRESERVATIVE	MATRIX CODE	ANALYSES REQUESTED	QC	CONDITION ON RECEIPT
	DATE	TIME								

COMMENTS:

COLLECTED & RELEASED BY	DATE	TIME	TURNAROUND TIME		
	/ /	:			
RECEIVED BY	DATE	TIME	RELINQUISHED BY	DATE	TIME
	/ /	:			
RECORD RETURNED BY	DATE	TIME			
	/ /	:	SHIPPING NUMBER:		

DISTRIBUTION: WHITE - PROJECT FILE / CANARY - LAB RECEIPT / PINK - DATA MANAGEMENT / GOLDENROD - FIELD

INFORMATION IN THIS SECTION FOR JACOBS USE ONLY

LOCATION	SAMPLE TYPE	DEPTH (FT.)	QC CODE

SAMPLING COMMENTS:

[illegible]